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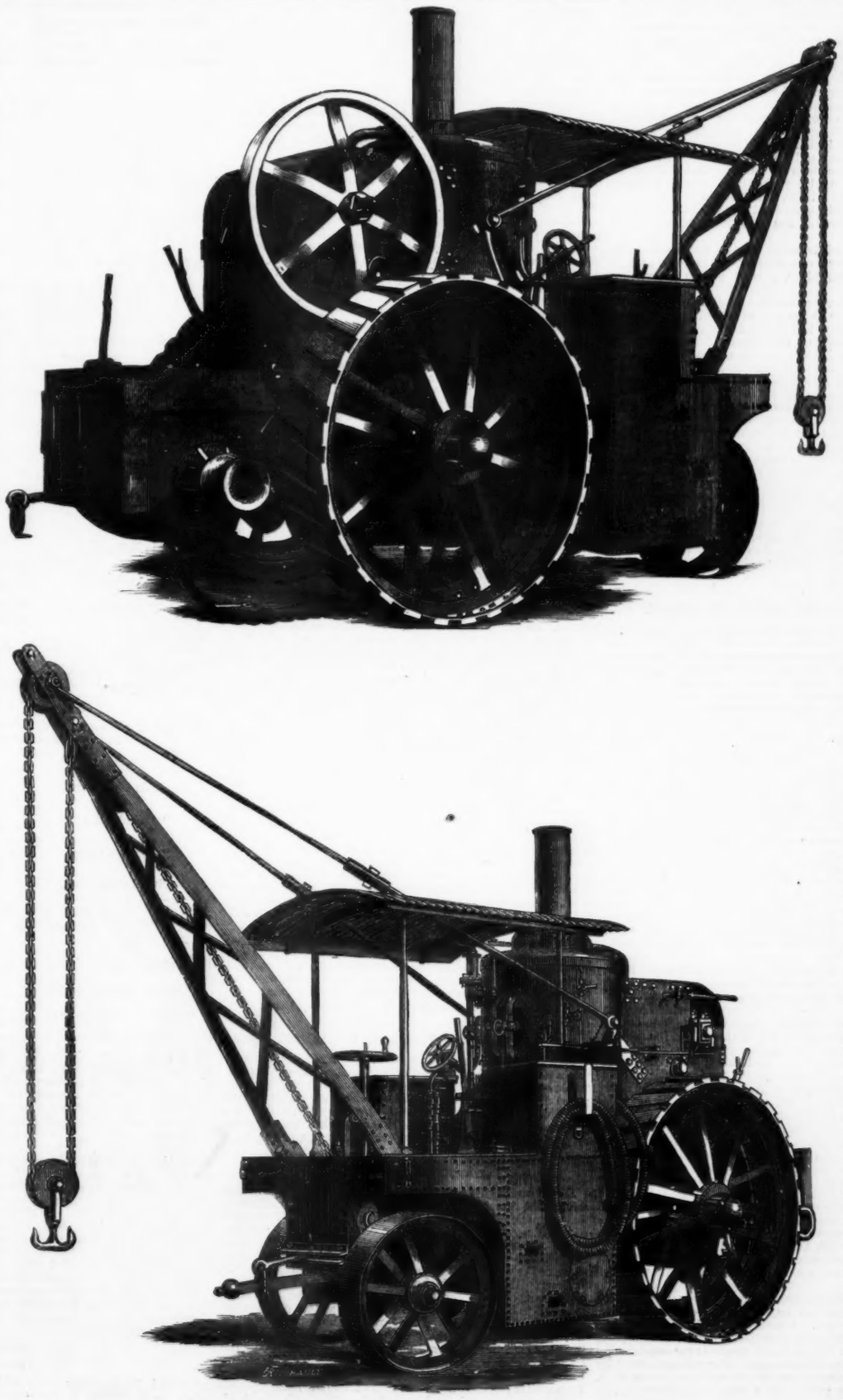
MILITARY TRACTION ENGINES.

DURING the latter part of last year, a series of experiments were carried out at Shoeburyness with a powerful and useful description of traction engine especially adapted for the conveyance of and mounting the heavy guns which now compose the siege trains of the English Government, this engine being one constructed by Messrs. John Fowler & Co., of Leeds, from the designs of Mr. J. A. C. Hay, the chief of the machinery establishment of the Ordnance Department.

The engine, illustrations of which we give, not only serves as a traction engine, being adapted for traveling on common roads, plowed or uncultivated land, but is also arranged for use as a locomotive upon the ordinary 4 ft. 8½ in. gauge railway. It is of 8 horse-power nominal, and has a single cylinder, which is supplied with steam at a working pressure of 150 lb. per square inch from a vertical (steel) boiler of the "Field" type. In addition to being adapted for use both as a road, traction, and locomotive engine, it is also provided with a number of special self-acting appliances, such as a 5-ton crane, wire rope-winding apparatus, bollards for working tackles, and a heavy fly-wheel pulley for driving steam machinery, all of which can, by very simple arrangements, be worked separately by the one engine. The whole of the gearing is of cast steel, and the main driving axle of the traveling wheels is fitted with a differential motion, which enables the engine to be turned in little more than its own length, and very readily round sharp corners. Motion to the gearing for working the crane chain and also the rope-winding apparatus and bollards is communicated from the engine crank-shaft by means of bevel gear connected with a worm and worm-wheel, so that the load when lifted or hauled up may be left securely suspended at any point without the intervention of brakes or ratchet wheels, a matter of no small importance. Moreover, while each appliance can be worked separately and distinct from the other, all may be thrown out of gear entirely, so that the crane chain and hook can be quickly lowered, or the fall ends of a set of blocks may be paid out by means of the bollards and a load allowed to descend very rapidly. In addition to this the steel winding rope may be used from either the front or back end of the engine; and when the winding drum is disengaged and out of gear, the rope can be rapidly uncoiled from the drum by hand; or if the loop end be made fast to a load, or held by hand, the wire rope will be uncoiled from the winding drum as the engine either advances or recedes.



EIGHT-HORSE POWER TRACTION ENGINE.

The driver occupies a position between the crane and boiler immediately over the front fore-carriage, and has the steering wheel and engine levers all within his reach; the boiler is also fed from the same platform; the upper portion of each side of the carriage and framing is constructed to form coal bunkers, while the lower part carries a supply of water. The principal dimensions of the engine are as follows:

Diameter of cylinder	10 in.
Length of stroke,	12 in.
Diameter of boiler,	3 ft. 3 in.
Height of boiler,	7 ft. 6 in.
Heating surface,	122 sq. ft.
Fire grate surface,	4·5 sq. ft.
Diameter driving wheels,	6 ft. 6 in.
Weight of engine, with water, coal, etc., complete,	12 tons.

The trials which have taken place were conducted by the military authorities, and the programme — a very interesting one — was intended, first, to ascertain what loads the engine would take over ordinary country roads; second, what loads could be taken over very soft marshy land direct by the engine and by means of hauling; third, what loads could be conveyed upon the ordinary 4 ft. 8½ in. gauge railway, and at what speed; fourth, for what general purposes the engine was adapted in addition to the above. In the first series a train was made up consisting exclusively of guns with their carriages, etc., as used on service and without any special appliances whatever — in all fourteen guns, weighing about 34 tons, were drawn by the engine over the country roads, through the village and marshes at the rate of four miles per hour. The engine was then used for mounting and dis-

mounting a 68-pounder gun, weighing 95 cwt., by means of the steam crane which is fitted immediately in front of the steering wheels. The gun was lifted from off its carriage and removed to a distance, hanging all the while from the crane jib, and was remounted on another carriage without any difficulty, although the ground over which the engine traveled in this case was the well-known Shoeburyness sand, into which the engine wheels sank deeply. An ordinary gun gin was then placed over a 12-ton gun; the fall of the lifting tackle was passed round one of the bollards with which the engine is fitted at the back end; the gearing being set in motion, the gun was quickly and easily raised, mounted, and dismounted in an incredibly short space of time. The bollards were also used for hauling a train of guns over 10 tons in weight from a distance, and the steel wire rope and winding gear were used for landing a 38-ton gun and carriage from a barge and hauling it up and over the sea wall, which has an incline of 1 in 16.

In the second series of trials a 40-pounder gun, weighing nearly four tons, and coupled direct on to the engine, was taken across the soft marsh, which was in a very wet and spongy condition, and afterwards the engine was taken over a soft broken part of the marsh, where it soon sank down until the ash-box and water tanks were deeply embedded. The winding gear was then brought into operation, when the engine soon hauled itself out of the hole and over the marsh by means of its own steel rope, subsequently hauling the gun over by the same means.

For the third series of experiments the crane and road wheels were removed, flanged wheels substituted, and buffers fixed to the front and back of main framing. The engine was then placed upon the rails of an ordinary 4 ft. 8½ in. gauge railway, and after drawing ordinary loads about at varying speeds, it was used for drawing a 38-ton gun and carriage up an incline of 1 in 40, which it did at a speed of four miles per hour. The same load was afterwards drawn by the engine on the level at the rate of eight miles per hour.

In the fourth series of tests the engine was found to be well adapted for driving a circular saw, the fan of a smith's portable forge, a general joiner, a set of pumps for raising water, etc.

These trials conclusively prove that much may be done by the mechanical engineer in the way of assisting the artillerist and military engineer in future campaigns, not only in bringing up and mounting, disembarking or embarking heavy guns, etc., with all their appurtenances, by means of traction engines, but when this work is finished the engine may be advantageously used either on the ordinary roads or on the railway line in bringing up to the camp supplies of ammunition, forage, rations, and other camp stores from the base of supplies, or in driving machines for cutting up timber, framing and putting the same together for siege operations or huts for the troops. It may also be usefully employed in raising water for supplying the camp or garrison, thus liberating the soldiers for other and more important duties; and there can be little doubt but that the general who is well furnished with such mechanical appliances in future wars will have a great advantage both as regards mobility and other important elements over the one whose army is not so furnished. Moreover, as the engine can be constructed to burn wood as well as coal, there should not be much difficulty in most countries in providing the necessary fuel.—*Engineering.*

MARINE ENGINES OF GREAT POWER.

IT is more than probable that the two great steamers City of Rome and Servia will be but the first ships of fleets—that, in other words, many ocean steamers of at least equal dimensions and equal power will be built; and no question excites more interest among marine engineers than those connected with the design and construction of the machinery intended to propel these huge hulls across the Atlantic at a speed not very far below that of a continental railway train. Three types of engine are available, and the choice lies among these. The engines may be made with two cylinders on the ordinary plan, only of very great dimensions; or with three cylinders, one high-pressure and two low-pressure; or with four cylinders arranged two and two, the high-pressure being above the low-pressure cylinders. There are two other arrangements, which, however, have hardly yet come up for discussion. We shall refer to these further on. Of the systems we have named only two are in favor just now, namely, the three-cylinder three-crank type, and the four-cylinder two-crank tandem type. An example of the first is supplied by the Orient, while several of the White Star boats furnish examples of the latter. Up to the present time it appears that the four-cylinder engine has done better and given more satisfaction than its rivals. So far as can be learned there is no great difference in the consumption of fuel; and all the great marine engines recently built, indicating 5,000-horse power and upwards, ought not to burn more than about 2 lb. of coal per horse-power per hour. This is not quite so small a consumption as has been reached in cargo steamers of moderate power; but it must be remembered that the colossal machinery of which we are speaking is not worked at that speed which is found most economical, but at that which drives the ship at the highest velocity. That is to say, the engines and boilers are always tasked to their utmost capacity, and this is not favorable to economy. The point in favor of the four-cylinder engine, then, is not superior economy of fuel; it is that all the ships which have been hitherto fitted with four-cylinder engines, such, for example, as the Britannic and Germanic, have made better passages than those ships like the Gallia or the Orient with three cylinder engines. This may be merely a matter of good luck for the one type of engines, and bad luck for the rival type. But the fact remains that engineers and shipowners alike seem to prefer the four-cylinder to the three-cylinder engine, and the performance of the engines of the Orient will strengthen their predilection. On her recent trip out and home to Australia, the Orient made, we understand, on her outward trip about 14 knots, and on her homeward voyage, with Australian coal and a dirty bottom, but 12 knots. We have not heard that her engines indicated more than 4,000 horses, which is considerably less than the anticipated power.

In designing marine engines of great power, the engineer has to consider what can be made and used with success, more than anything else. A multiplicity of cylinders would not be employed if it could be dispensed with; but practical difficulties stand in the way, and preclude the construction of engines of the two-cylinder type. For example, the City of Rome will have three low-pressure cylinders, each 86 in. in diameter. The gross piston area is therefore 17,427 square inches. A single piston of this area would be no less than 12 ft. 5 in. in diameter. To make such a cylinder at all would be a very difficult task, and it is more than likely that before it had been in work for a month it would crack. Cylinders of 120 in. in diameter are the very largest that can be used with any fair prospect of success at sea.

Again, taking the pressure in the large cylinder at 20 lb. on the square inch, the gross load on the piston 12 ft. 5 in. diameter, would be more than 154 tons, to carry which the piston must be enormously heavy. The subdivision of the power among a number of cylinders is absolutely necessary, and it would be necessary even though the system was directly opposed to economy in the consumption of fuel. In the case of the four-cylinder type of engine, we proceed on a totally different basis from that pertaining to the three-cylinder engine. This last with its three cylinders must be regarded as one engine, and power can only be augmented by increasing the dimensions of all three cylinders and their appurtenances. With the four-cylinder, or more strictly speaking, the two-cylinder tandem type, each pair of cylinders constitutes a distinct engine; and the augmentation of power can be effected not only by increasing the diameters of the cylinders, but by using more engines. Each pair of cylinders may be treated as a unit, but with the three-cylinder type each set of three cylinders is a unit, and obviously a much larger and more unwieldy unit. The Britannic has two units. The Inman steamer City of New York, engined by the North-Eastern Engine Company with Allan's patent engines, indicating 2,600-horse power, and illustrated in *The Engineer* for January 4, 1878, has two units. More power being wanted in the City of Rome than in either of the vessels we have named, the number of the units is augmented to three; and we find accordingly three engines, each practically independent of its fellows, all working on the same crank shaft. This system has, in our opinion, substantial advantages over the three-cylinder type, not the least being that six cylinders are employed to do the work, and this without any practical increase in the complexity of the machinery. If the City of Rome had been propelled by a three-cylinder engine, then the two low-pressure cylinders must each have been 105¼ in. in diameter, while the high-pressure cylinder would have a diameter of 75 in. Most engineers would prefer to have charge of three 86 in. pistons rather than of two 105 in. pistons. As regards the strains on the crank shaft, everything is in favor of the tandem engine. The number of cranks is the same in both cases. The maximum strain for the three-cylinder type may be taken as that falling to the share of the high-pressure piston. It will amount with an initial cylinder pressure of 100 lb., corresponding to, say, a safety valve load of 90 lb.—from which is to be deducted the receiver pressure, which may be taken at 20 lb.—to about 155 tons. The maximum strain in the rival type will be that on the high-pressure piston, equal—pressures remaining as before—to less than 60 tons, to which must be added the load on the low-pressure piston, which will at the most be another 60 tons, or 120 tons in all. The maximum strain due to the low-pressure pistons of the three-cylinder engine will be about 77 tons; from which it will be seen that the work is more equally distributed among the cranks by the tandem engine than by the three-cylinder engine. It is not impossible that if the net power delivered to the screw were measured, it would be found that the double-cylinder unit type, or vertical tandem engine, wastes less in overcoming its own resistance than its rival; and this may account for the apparently superior performance of the former.

We have still remaining two types of high-powered marine engines for consideration. These are the double-cylinder non-tandem unit, and the non-compound engine. The first consists simply of the ordinary two-cylinder compound engine. By increasing the number of such engines working on one crank shaft it is obvious that any required power can be obtained without dangerously or inconveniently augmenting the size of the cylinders; but this arrangement cannot compare in convenience with the tandem type. It has against it the fact that it requires double the number of cranks, and that its adoption renders a long engine-room and great waste of valuable cargo space a necessity. It is very unlikely, therefore, that it will ever be adopted extensively or on a large scale. Its advantages are, very equable turning of the shaft, and a low center of gravity, which in the case of ships of war at all events, is worth having at some cost. It may appear to require some courage to say a word in favor of the non-compound type, yet the moment we are compelled to use more than two cylinders the greatest objection which has been urged against the system, namely, the large initial strains proper to it, falls to the ground; and if we are allowed to use four cylinders, or even three cylinders, very high powers may be had without any undue stress being thrown on any part of the engine. It must not be forgotten that although it is assumed that a single cylinder, to do the same work as a compound engine, must have the same diameter as the low pressure cylinder of the latter, this requires qualification; because, owing to various and well-understood causes, under the same conditions of expansion and initial pressure, the single piston may have an area 20 per cent. less than that of the low-pressure piston of a compound engine of the same power. Much may be urged in favor of the non-compound system for very high powers, and we may return to the subject at another time.—*The Engineer.*

DESIGN FOR THE FORTH BRIDGE.

THE studies for this design were commenced last autumn, when some data as to the suspension bridge became known. Their object was to ascertain whether a bridge of the proposed dimensions could be built with absolute safety during erection as well as during its future existence, and with a moderate degree of economy. These studies were carried on as a matter of general engineering interest, and they have now come to a conclusion.

I. GENERAL DESCRIPTION.

Over two lengths of 1,600 ft. each, the water is of such depth that foundations are supposed to be impracticable. Between these lengths of 1,600 ft. is a space of shallow water of 588 ft. Accordingly there is a central arch of 400 ft. between two masonry piers 94 ft. each, then follows on each side an arch of 1,600 ft. clear span, after which, on each side, there are two openings spanned by a continuous girder 650 ft. long. Towards each shore there are other smaller spans.

The principle of construction applied to the two large spans of 1,600 ft. each may be described as that of a flexible arch braced by a girder. The arch is not quite flexible, having a thickness at the crown of 18 ft. and at the springing of 40 ft., but it would not be rigid enough to take the tranverse strains from the moving load. It is, therefore, braced by a girder which has a peculiar and novel shape. Its peculiar features are, that part of one of its flanges coincides with the arch, and part of the other with the horizontal platform of the bridge, and that its depth varies very nearly in proportion to the moments from the moving load. In consequence of its shape and its position with regard to the arch it becomes also an important element in the erection of the bridge, as will be described hereafter. The springing of the arch is at high-water mark, and its crown about 400 ft. above. The proportion of rise into span is, therefore, about 1 and 4. The platform of the bridge is about 150 ft. above high-water mark. It is made of timber and rests upon cross-girders and rail girders. These are carried by parapet girders 11 ft. deep and 20 ft. apart, which are suspended from the arch at intervals of 67 ft. The platform passes at two points through the arch where the parapet girders are firmly fixed. At its ends it rests by means of columns upon the arch at its springing, and in the center it is cut so as to allow for expansion by temperature.

There are two platforms and consequently two arches and two bracing girders at a distance of 120 ft. between centers, each system being about 20 ft. wide. The two systems are braced together on the one hand by a bracing which follows the line of the arch, on the other by a horizontal bracing at the level of the platform, and there are besides several braced frames vertically across the two systems. Each system is double, and bracing is placed in all parts between its two elements. The entire structure is of steel, the arch proper being of steel with 36 tons breaking strain, the rest of the structure with 30 tons breaking strain.

CALCULATION.

Forces and Strains.—The forces are the following:
The dead weight (assumed) B=7·5 tons per lineal foot.
The moving load (two trains) M=2·5 " "
The wind pressure (33·6 lb.) W=0·015 ton sup. foot.

The expansion by temperature:
(Modul. elast.×expansion per 1 Centigrade) T=0·15 ton per square inch.

The dimensions are the following:

Span	l=1,640 ft.
Rise of arch	h= 395 "
Mean width of bridge	b= 120 "

Surface for wind pressure according to elevation=

$$\left(\frac{2}{3}\,0{\cdot}08d+1{\cdot}5\right)l \text{ sup. ft.}$$

Surface of railway train=10 l sup. ft.

The horizontal force under the total load B+M=10 tons is:

$$\frac{10\times1640^2}{8\times395}=8500 \text{ tons.}$$

Moment of inertia of net section through crown J=370,645 sq. in.-ft.
" resistance of top flange= 24,719 sq. in.-ft.
" " middle " =123,595 " "
" " bottom " = 9,610 " "
Total net area of flanges a=1,245 sq. in.
Moment of moving load at crown=

$$0{\cdot}03\times2{\cdot}5\left(\frac{1640}{2}\right)^3=50{,}430 \text{ foot-tons.}$$

tons per sq. in.

$$\text{Strain in top flange}=+\frac{50{,}430}{24{,}719}+\frac{1062}{1245}=+2{\cdot}88$$

$$\text{" middle " }=-\frac{50{,}430}{123{,}595}+\frac{1062}{1245}=+0{\cdot}45$$

$$\text{" bottom " }=-\frac{50{,}430}{9610}+\frac{1062}{1245}=-4{\cdot}40$$

Temperature:
Average moment of inertia of arch and girder T_1=559,800 sq. in.-ft.

$$\text{Horizontal force}=\frac{T\times a\times t^0}{1+\frac{a}{4}\frac{h^2}{J_1}}=\frac{0.15\times1245\times t^0}{1+\frac{1}{4}\frac{1}{3}47}=5{\cdot}86\,t \text{ tons}$$

Position of horizontal force below crown=$\frac{1}{3}$ h=131 ft.
Moment of horizontal force=131×5·86 t.
t=20.

tons per sq. in.

$$\text{Strain in top flange}=\pm\frac{131\times5{\cdot}86\,t}{24{,}719}+\frac{5{\cdot}86}{1245}t=\begin{cases}+0{\cdot}71\\-0{\cdot}53\end{cases}$$

$$\text{" middle flange}=\mp\frac{131\times5{\cdot}86\,t}{123{,}595}+\frac{5{\cdot}86}{1245}t=\begin{cases}-0{\cdot}03\\+0{\cdot}23\end{cases}$$

$$\text{" bottom flange}=\mp\frac{131\times5{\cdot}86\,t}{9610}+\frac{5{\cdot}86}{1245}t=\begin{cases}-1{\cdot}50\\+1{\cdot}68\end{cases}$$

SUMMARY.—*Strains in Tons per Square Inch.*

Strains.	Moving Load.	Temperature.	Dead Load.	Total.
Strain in top flange.	+2·88	+0·71 / −0·53	+4·50	+8·09 / −6·85
" middle flange	+0·45	−0·03 / +0·23	+6·83	+7·25 / +7·51
" bottom flange	−4·40	−1·50 / +1·68	+7·90	+2·00 / +5·18

The moment from the moving load increases towards a point at a distance from the center equal to about one-fourth of the span, where it is about double; it then diminishes and increases once more towards the springing. The strains from wind pressure are not here stated, as they are contained in the calculation of weight further on.

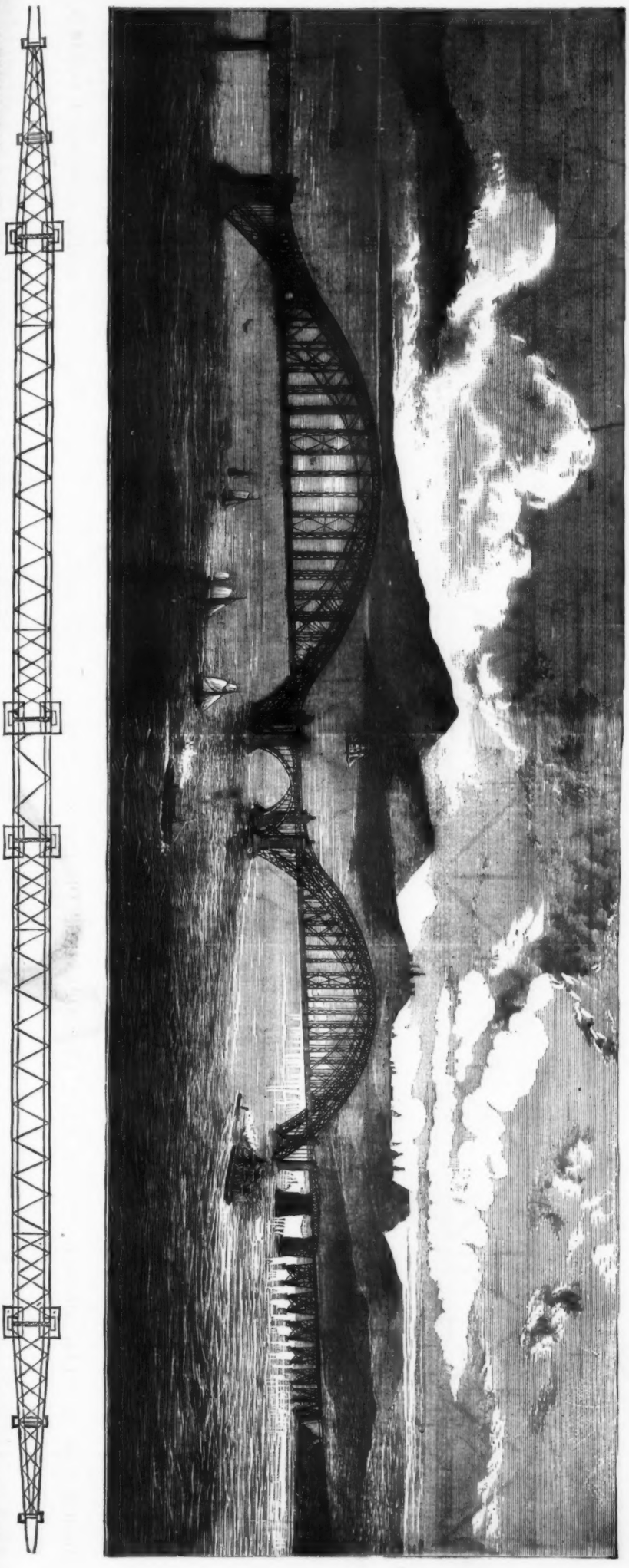
The above calculation is an approximate one; the exact calculation is laborious, but at the present state of the theory of elasticity quite feasible, and may be treated graphostatically as well as algebraically. The plan to treat the structure as a whole, *i.e.*, as an arch fixed at the springing with varying sectional moment of inertia, would be a better one than to treat it as a compound structure.

Strength.—In the choice of the coefficients of strength, which indicate how many tons come upon a square inch, a new method has been followed which takes into consideration the action of repeated strains, a railway bridge being a structure exposed to repeated strains.

We shall take an early opportunity to treat this subject a little more fully than is possible in the present article, and simply state here the formula for the coefficient according to Professor Weyrauch:

$$S_1=\frac{n}{10}S\left(1+\frac{\text{min. strain}}{\text{max. strain}}\right),$$

where S is the breaking strain of iron or steel respectively, when applied once, S_1 the strain which when repeated a great number of times will break a bar. The coefficient of safety is here determined by the assumption that the maxi-



DESIGN FOR A STEEL ARCHED BRIDGE, WITH TWO OPENINGS OF 1600 FT. SPAN, FOR THE FIRTH OF FORTH.—MR. M. AM ENDE, ENGINEER, LONDON.

mum strain be double the minimum strain which represents an ordinary case. In that case would be:

$$S_1=\tfrac{2}{3}S.$$

Taking now a fourfold safety, *i.e.*, taking the coefficient of strength,

$$s=\tfrac{1}{4}\,S,$$

the formula will be:

$$s=\frac{S}{6}\left(1+\tfrac{1}{2}\frac{\text{min. strain}}{\text{max. strain}}\right).$$

Parts made of steel with 36 tons breaking strain are accordingly calculated with the formula:

$$s=6\left(1+\tfrac{1}{2}\frac{\text{min. strain}}{\text{max. strain}}\right).$$

For most parts composing the arch for example:

$$s=6(1+\tfrac{1}{2}\tfrac{2}{3})=8{\cdot}25 \text{ tons per square inch.}$$

Parts made of steel with 30 tons breaking strain are calculated with the formula:

$$s=5\left(1+\tfrac{1}{2}\frac{\text{min. strain}}{\text{max. strain}}\right).$$

For the vertical bars, for example, by which the platform is suspended:

$$s=5\left(1+\tfrac{1}{2}\frac{0{\cdot}9}{3{\cdot}4}\right)=5{\cdot}66 \text{ tons per square inch.}$$

For certain bars in the bracing of the arch, which receive alternately a tensile and a compressive strain of equal intensity:

$$s=5\ (1-\tfrac{1}{2})=2{\cdot}5 \text{ tons per square inch.}$$

On the other hand, for the braces of the wind structure which receive the maximum strain only once or a few times:

$$s=\tfrac{1}{4}\,S=7{\cdot}5 \text{ tons per square inch.}$$

Weight of Structure.—Coefficients:

Proportion of gross sectional area (including connections) to net area as 1·4 to 1.

Weight of steel bar, 1 ft. long 1 square inch area = 0·0015 ton.

Weight of all secondary bracing in structure $=\dfrac{b\,h}{30{,}000}$ tons per lineal foot.

Weight of arch, assuming it approximately to be a parabola, and $s=8{\cdot}25$,

$$\frac{1{\cdot}4\times0{\cdot}0015}{s}(7{\cdot}5+2{\cdot}5)\left(\frac{l^2}{8h}+\tfrac{2}{3}h\right)=$$

2·9 tons per lineal foot horizontally.

Weight of bracing girder (only one flange taken), moment (as above)=50,430 foot-tons, depth=53 ft., $s=5$, weight of flange $=\dfrac{1{\cdot}4\times0{\cdot}0015\times50{,}430}{53\times s}=0{\cdot}385$ ton per lineal foot.

Weight of bracing, consisting of verticals and diagonals of an average angle of 45 deg.; average shearing force $=0{\cdot}1\,M\,l$, $s=4$,

$$\frac{1{\cdot}4\times0{\cdot}0015\times0{\cdot}1\,M\,l}{s}=0{\cdot}126 \text{ ton per lineal foot.}$$

Weight of suspension bars; average length = 100 ft., $s=5{\cdot}66$, weight suspended = 3·4 tons per lineal foot,

$$\frac{1{\cdot}4\times0{\cdot}0015\times3{\cdot}4\times100}{s}=0{\cdot}119 \text{ ton per lineal foot.}$$

Wind Structure.—The flanges of the wind structure coincide with other parts of the structure which are strained with less than $s=\frac{1}{4}$ S. They can, therefore, be calculated with a wind pressure of 0·010 ton per superficial foot, while the bracing is calculated with 0·015 ton per superficial foot. According to a calculation which cannot be given in this article for want of space, the weight of the wind structure is:

Weight of flanges =

$$\frac{0{\cdot}0015\times1{\cdot}4}{s}\times\frac{2}{3\,4\,3}\times\frac{0{\cdot}010}{l}\left(\frac{l^2h}{5}+\frac{h^3}{2}\right),$$

Weight of bracing=

$$\frac{0{\cdot}0015\times1{\cdot}4}{s}0{\cdot}015\left(\tfrac{5}{12}\,l\,h+\tfrac{5}{6}\,\frac{h^3}{l}+\tfrac{5}{12}h^2\right)$$

Each of these quantities has to be multiplied by the proportion of the surface exposed to wind pressure to the gross surface inclosed by the parabola and its base line, which is $\frac{2}{3}\,h\,l$. The surface exposed to wind pressure is composed of the fourfold surface according to elevation and one railway train (see above). Hence:

$$\text{Weight of flanges}=\frac{4\,(\tfrac{2}{3}\times0{\cdot}08\,h+1{\cdot}5)+10}{\tfrac{2}{3}\,h}\times$$

$$\frac{0{\cdot}0021}{9}\times\frac{2}{3\,4\,3}\times\frac{0{\cdot}010}{b}\left(\frac{l^2h}{5}+\frac{h^3}{2}\right)=0{\cdot}69 \text{ ton per lin. ft.}$$

$$\text{Weight of bracing}=\frac{4(\tfrac{2}{3}\times0{\cdot}08h\times1{\cdot}5)+10}{\tfrac{2}{3}h}\times$$

$$\frac{0{\cdot}0021}{7{\cdot}5}\times0{\cdot}0015\left(\tfrac{5}{12}\,l\,h+\tfrac{5}{6}\,\frac{h^3}{l}+\tfrac{5}{12}h^2\right)=0{\cdot}502 \text{ ton per lineal foot.}$$

Weight of lateral bracing (see above) $=\dfrac{b\,h}{30{,}000}=1{\cdot}6$ tons.

Weight of all platform girders calculated from design—0·45 ton per lineal foot.

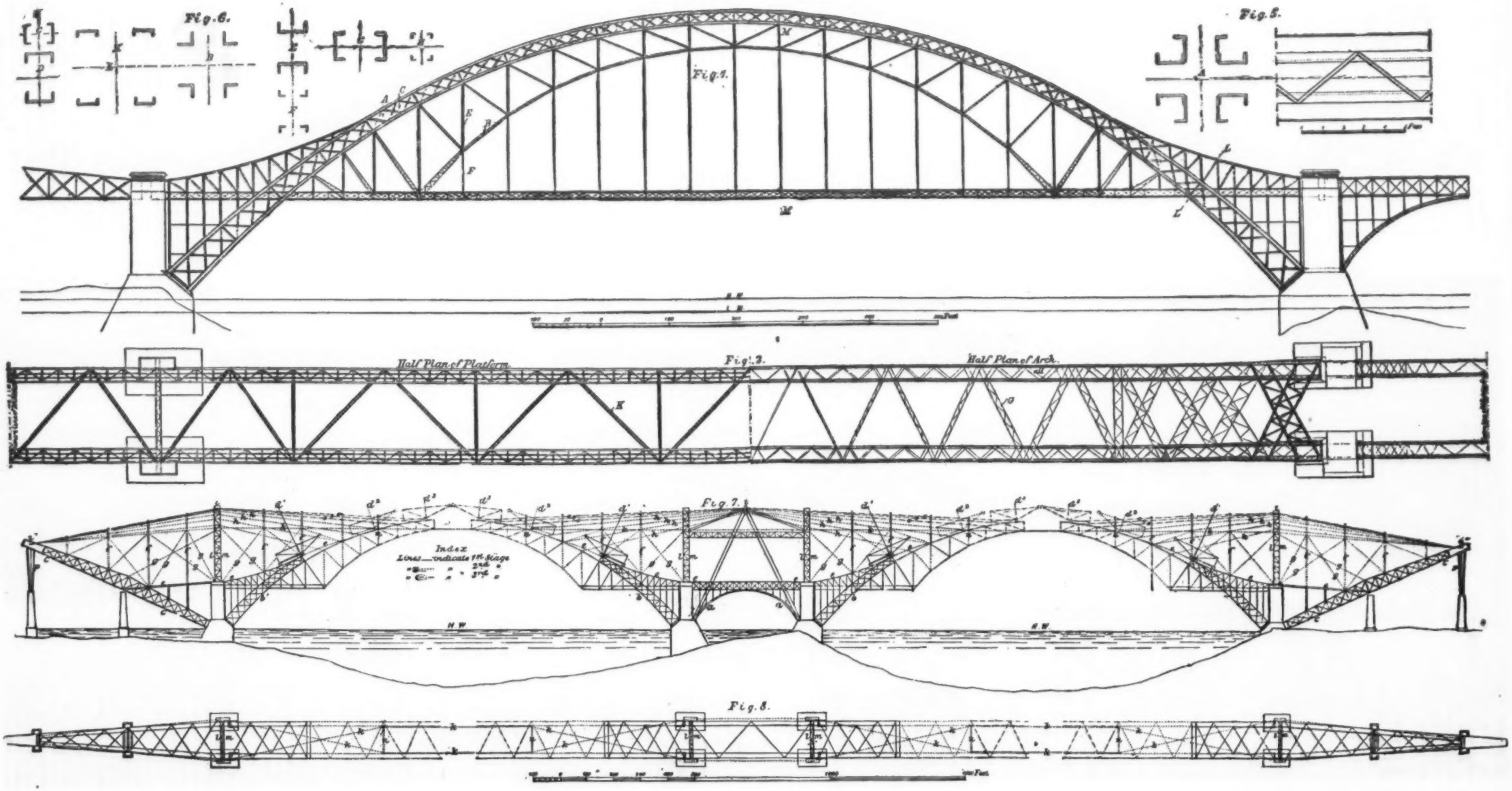
Summary:

	Tons per lineal foot.
Weight of arch	2·900
" bracing girder (flanges)	0·385
" " (bracing)	0·215
" suspension bars	0·126
" wind structure (flanges)	0·690
" " (bracing)	0·502
" lateral bracing	1·600
" platform girders	0·450
" timber, platform, and rails	0·430
Contingencies	0·292
Total weight	7·500

Stability against Overturning.—The stability of the bridge is the smallest when a light railway train of great superficial area covers the leeward roadway, where its weight would have no effect upon the moment of resistance against overturning, the fulcrum being assumed to lie in a vertical plane which goes through the center line of the leeward roadway.

The surface exposed to wind pressure then consists, for the piers of one arch, of the surface of the steel structure of the large span plus the surface of half the central span and a portion of the adjoining shore span multiplied by 4, plus the surface of four stone piers.

$$4(29{\cdot}5\times1660+11\times380)+10\,(1660+380)+4\times7500=$$
$$216{,}520 \text{ sup. ft.}$$



DESIGN FOR A STEEL ARCHED BRIDGE, WITH TWO OPENINGS OF 1,600 FT. SPAN, FOR THE FIRTH OF FORTH.—MR. M. AM ENDE, ENGINEER, LONDON.

The center of gravity lies 169 ft. above the fulcrum. Hence the moment of overturning is:

$$216,520\times169\times W=36,591,800W=548,878 \text{ foot-tons.}$$

W being, as before, 0·015 ton.

The moment of resistance consists of the weight of bridge and train multiplied by its leverage (60 ft.) plus so much weight of the masonry piers as can be conveniently brought into action by two cross frames, which are anchored down into the masonry, the latter acting on a leverage of 160 ft. Thus:

$$\text{Moment of resistance}=(7·5\times1660+1·4\times380)60+750\times160=838,920 \text{ foot-tons.}$$

Hence

$$\frac{\text{mom. of resistance}}{\text{mom. of wind pressure}}=\frac{838,920}{548,878}=1·528,$$

indicating that the assumed wind pressure of 33·6 lb. should be multiplied with 1·528.

At the same time it should be mentioned on the one hand, that the surface is taken very full, and on the other that the wind pressure will not be so great on the second, third, and fourth surfaces as on the first, lying, as these do, one behind the other, but that the decrease will be at the ratio of about 1 to 8, which is the proportion of the surface, as seen in the elevation to the gross surface marked by the outline of the structure. The aggregate of the wind pressure on the four surfaces is, therefore, only:

$$\left(1+\frac{7}{8}+\frac{7\times7}{8}+\frac{7\times7\times7}{8\times8\times8}\right)\frac{W}{4}=\frac{3·3}{4}W,$$

and the total moment is therefore reduced to

$$\frac{511,558\times3·3}{4}+37,320=450,353 \text{ foot-tons.}$$

Accordingly the wind pressure which would overturn the structure is (W being 33·6 lb.),

$$\frac{838,920}{459,353}W=61·3 \text{ lb. per superficial foot.}$$

Making this calculation in the usual way with a single surface, the moment of the wind pressure would only be 10,743,410 W; hence the wind pressure which would overturn the structure would be:

$$\frac{838,920}{10,743,410} \text{ tons}=0·0781 \text{ ton}=175 \text{ lb.}$$

II. DESCRIPTION OF DETAILS.

In a project such as the one before us, it would be superfluous to describe the details in the manner generally adopted for the structures which have been carried out. The accurate calculation which precedes and goes hand-in-hand with the production of the working drawings would no doubt necessitate many modifications. But some general principles for the design of the details can here be stated:

1. The sectional area of parts in compression, as well as those in tension, is determined by adding to the net area the area occupied by rivet holes.

2. All connections are made by means of rivets, and therefore hinged connections are avoided as much as possible. At the connections the sectional area of the rivets is sufficient to transmit the whole strain, compressive as well as tensile.

3. Struts are calculated according to Gordon's formula, but if Weyrauch's formula (as stated in our article of last week) gives greater sectional areas, the former is not applied.

4. All primary parts, such as the flanges and the bracing bars of the arch, the flanges and the bracing bars of the bracing girder, the suspension bars and the bars constituting the wind bracing, are constructed of box shape. In Figs. 5 and 6 the cross sections of some of these parts are illustrated, the letters referring to Figs. 1 and 2. Most of the secondary and tertiary parts which constitute the bracing between the four edges of the box-shaped parts are simple rolled bars, *i. e.*, ⌊ —, ⌊, or flat bars of suitable dimensions.

5. Except at the connections, and in some parts of the platform, no plates are used in the structure. The interior of the parts is therefore not in darkness, but open to minute inspection throughout the whole structure, as well as accessible to the paint-brush.

6. Careful painting being an all-important factor in the preservation of a structure of iron or steel, provision is made for the effectual performance of this service by means of a carriage rolling along the top flange of the arch, from which adjustable stages are suspended. A carriage would also roll upon the inside of the bottom flange of the arch for the painting of that part of the structure.

The lower part of the arch, to about 50 ft. above springing, being exposed to the action of salt water, should be specially protected either by constructing it of a different material, for example, stone, or otherwise.

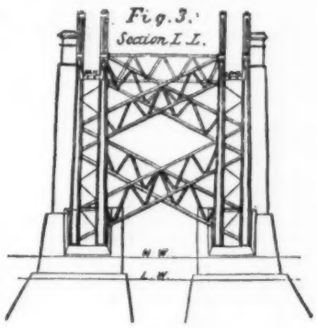
III. PROCESS OF ERECTION.

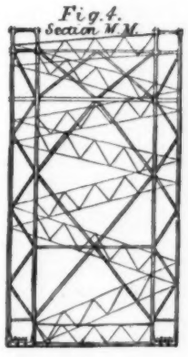
In the erection of a structure of such gigantic dimensions as here described, it is of the utmost importance that success should not be dependent on good fortune, such as calm weather or swift progress of the work. It was, therefore, incumbent on the designer to devise on the one hand a structure which in its incomplete condition offers, together with its temporary supports, a stability not inferior to that of the finished structure, and on the other hand a mode of erection which is simple and which might be interrupted without danger at any time.

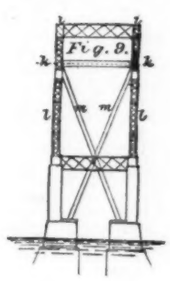
The erection of the two arches is undertaken simultaneously, and is divided into three stages. Figs. 7, 8, and 9 show the first stage in full lines, the second in dotted lines, and the third in dot and dash lines. These three stages lead up to the closing of the arches, after which there can be no doubt as to the successful completion of the whole.

For the completion of the first stage hardly any staging or auxiliary parts are required. The central arch is erected by connecting its bracing girder over the piers with such parts of the springing of the adjoining main arches as may be required to balance its projecting weight until the meeting of its two halves is effected; *e e* is made a working platform, and the erection of the springing at *b b* is accomplished with the assistance of the bracing girder. The parts are one by one lowered into their position by means of derricks. Meanwhile the two continuous girders, *c c*, nearer the shores, have been launched into a horizontal position, and rest in their centers upon pivots turned down, as shown on the diagram, their down ends being secured to the masonry of the abutments. A platform, at the same time forming a tie, *d d*, is placed between the pivot and the top flange of the bracing girder of the main arch, and made to rest by means of columns on the turned down girder. The erection of the springing of the main arches, *b b*, can now be proceeded with. This completes the first stage.

The second stage deals with the erection of a section of the bracing girder of the main arch, which consists of four panels, 67 ft. long each, the upper flanges of the main arch and part of the lower flanges being now omitted, as they would be an unnecessary burden of dead weight. During this process some staging is required. Upon each of the four masonry abutments verticals, *l l*, are erected and anchored down to the masonry, and it is part of the scheme that these should be parts of the final structure, which can temporarily be spared, as, for example, the platform girders. Diagonal struts, *m m*, and horizontal girders complete the frames, which are shown in Fig. 9 in elevation; next, the two central frames are connected and braced together in the manner shown in Fig. 7, while the two frames nearer the shore are held in position by guy-ropes. Uprights, *f f*, are also erected at suitable distances from each other, and they are made of the suspension bars (or posts) for the platform, which can then be spared. They are intended to hold laterally in position the wire ropes, *k k* and *o o*. Their width is 20 ft., and, if properly connected with the structure at the platform, *e e*, would have in themselves sufficient lateral strength; longitudinally, they are held in position by guy-ropes, *g g*. The working platform, *e e*, is extended forward and transferred from the top flange to the bottom flange of the arch. The derricks take position at the extreme point. Each fresh panel when completed is taken hold of by wire ropes, which pass through the posts, *f f*, and over the frames, *l m*, meeting in the center at *i* and to the right and left at *i' i'* and *i'' i''*. At these points are adjusting screws, each rope having attached to it an adjusting screw not larger than can be conveniently worked by hand. At *i'' i''* other wire ropes, *p p*, are attached, by means of







which an anchorage with the masonry piers at those points is effected.

Arrived at the end of the second stage of erection, there is still in each arch a gap of 536 ft. The process described above might now be continued with sufficient safety, as the stability against wind pressure of the structure at this stage is scarcely inferior to what it will be when completed; but, to render success beyond doubt, a new element is now introduced in the shape of two horizontal wire ropes, *k k*. There are two sets of these ropes, one for each of the two bridges, 120 ft. apart. They are fixed to the extreme points of the arches, where a temporary strut, *n*, is placed between them. They then cross each other on each side, and are fixed to the frames, *l m*, as shown in plan, by means of adjusting screws. Being of steel, they can be tightened up, so as to have a deflection of only 5 ft. in the gap of 536 ft. In consequence of this arrangement, the wind pressure upon the arches is transmitted to the frames, *l m*, and their resistance against overturning may be regulated according to requirement. It is calculated that by means of these horizontal ropes the projecting ends of the arches would be held so steadily that the third stage of erection could be accomplished with as much security as the other two stages. In the closing of the arch a difficulty has still to be overcome, which arises out of the changes of temperature; but if the arches, or rather the bracing girders, are erected at a slightly higher elevation than they would assume after their closing, and if this elevation is throughout the operation watched by leveling instruments, together with observations of the temperature of the air, it will be possible, not only to put in the keystone piece of the arch, but also to adjust it so that when left to itself the arch will receive its horizontal strain in that position which is made the basis of the calculation.

IV. GENERAL REMARKS.

If the design described in this article appears to be put forward as the best solution of the problem of throwing a bridge across the Firth of Forth, this should not be accepted without qualification. The results of careful soundings of the river bed, together with investigations as to whether or not foundations may be made with advantage at a greater depth than engineering practice has dealt with hitherto, or, at least, whether or not the assumed positions of the piers may be altered with a view of shortening the spans, would possibly lead to modification of the design here proposed. The object of the present articles is merely to compare the merits of an arch bridge with those of a suspension bridge of given general dimensions for a given locality, or rather to show that the advantages are, without exception, on the side of an arch bridge.

The points of comparison are: 1. Rigidity under the moving load. 2. Rigidity and stability under wind pressure. 3. Safety during erection. 4. Height of structure. 5. Economy. 6. Duration.

1. *Rigidity under the Moving Load.*—A moderate, and, it may be said, sufficient, rigidity under the moving load, can be accomplished in a suspension bridge with a curved chain if the horizontal girder is made of sufficient strength and of the shape most suitable for the purpose, but, as already stated, the only two absolutely fixed points in a suspension bridge, viz., the anchorages of the chains, lie far beyond the span of the bridge. In an arch, even if it were hinged at the springing, the two fixed points would be in the hinges; but if it has a flat base, as in the present case, the fixed points lie virtually even within the span of the bridge. The bracing of the arch can be effected by a structure which is firmly attached to it instead of being suspended from it.

2. *Rigidity and Stability under Wind Pressure.*—The girder which is intended to brace the flexible suspension structure can only partially moderate the oscillating effect of the wind pressure upon it; the corresponding effect upon the arch would hardly be perceptible. The stability of the structure against overturning from wind pressure is simply a question of ratio between the moment of the wind pressure and the moment of the weight of the structure, consequently it is a question of ratio between height of center of surface exposed to wind and base. It can, therefore, not be a matter of doubt that widening the base must have the same effect as, or a better effect than, reducing the height. A suspension bridge of the proposed height of 150 ft. above high water can certainly be made of sufficient stability by making the base broad enough, and as there is no limit to this for all practical purposes, the reduction of height, if such were intended, would be a short-sighted measure. With regard to the arch, the position of the roadway is of much less consequence.

3. *Safety during Erection*—This point has been discussed both with regard to the suspension bridge and to the arch bridge.

4. *Height of Structure.*—The extreme height of a suspension bridge, the curved chain of which deflects to a point 150 ft. *above* high-water mark, must obviously be 150 ft. greater than that of an arch bridge of the same proportions which springs *at* high-water mark.

5. *Economy.*—Assuming—as approximately is the case—that each span of the suspension bridge consists of a parabolic chain with a deflection of 1 in 4, two towers and two anchorage chains, inclined under an angle of 45 degrees, the theoretical volume of these parts from the platform upwards will be:

$$\text{Parabolic chain, } \frac{B_1+M}{s}\left(\frac{l^2}{8h}+\frac{2}{3}h\right)$$

$$\text{Towers . . . } \frac{B_1+M}{s}\frac{l^2}{3}$$

$$\text{Anchorage chains, } \frac{B_1+M}{s}\frac{l^2}{2}$$

$$\text{Total, } \frac{B+M}{s}\frac{5}{3}l^2$$

where B_1 would be the dead weight per lineal foot to be supported by the curved chain between the towers, and M the moving load—2·5 tons.

The theoretical volume of the arch will be:

$$\frac{B+M}{s}\left(\frac{l^2}{8h}+\frac{2}{3}h\right)=\frac{B+M}{5}\frac{2}{3}l^2$$

where B—7·5 tons as stated before.

Supposing both bridges constructed according to the same coefficients of strength, B_1 (for the suspension bridge) cannot be taken at less than 6 tons. The above theoretical volumes are then

$$\frac{8·5}{s}\frac{5}{3}l^2=\frac{14·2}{s}l^2$$

and

$$\frac{10}{5}\frac{2}{3}l^2=\frac{6·6}{s}l^2$$

respectively.

From the statement of weights per foot lineal of the arch bridge it follows that the weight of parts, other than the arch, is 4·168 tons per foot lineal; the corresponding item for the part of the suspension bridge which is between the towers being at least 2·9 tons. If these figures are reduced to theoretical volumes and added to the quantities above, we have

$$\text{For the suspension bridge, } \frac{14·2}{s}l^2+\frac{6·6}{s}l^2=\frac{20·8}{s}l^2$$

$$\text{“ arch “ } \frac{6·6}{s}l^2+\frac{9·6}{s}l^2=\frac{16·2}{s}l^2.$$

The volume of the suspension bridge has still to be increased by the volume of all bracing between the tower and the anchorage chains, as well as by the volume of parts below the platform. If this item is put down at least at $4·4l^2$ the proportion of volumes will be as 252 to 162.

If then the weight of the two arches is, according to previous statements about 7×3280=22,960 tons, the suspension bridge may be expected to contain at least 35,490 tons, supposing it to be constructed on the same principles of strength as the arch bridge. It should, however, be mentioned that the quantity of masonry required would be somewhat larger in the arch bridge than in the suspension bridge.

6. *Duration.*—Although structures, the principal carrying parts of which have a tensile strain, such as suspension bridges or girder bridges, are constructed in great number,

so that we are now quite accustomed to trust in their safety, most of these structures are not yet old. When the time comes—and it has come in some cases—where uncertainty arises as to the condition of parts of the structure, which could not be looked after and painted so carefully as is desirable, or which may contain flaws or other local defects difficult to detect, our confidence will begin to be weakened, especially with regard to parts in tension. Parts purely in compression will naturally be looked to with much greater confidence, for it cannot be imagined that a well-designed structure will break down without warning from defects in compressed parts unless such defects are plainly apparent. For this reason arch structures should be preferred to girders or suspension structures whenever the locality permits of their being executed.

From the information which we possess with regard to the Firth of Forth, the form of the river bed is eminently suited for the erection of an arch bridge, and as we cannot suppose that a fair trial was not given to the arch as well as to the continuous girder, we are bound to ascribe either to caprice or to an undue admiration for some prominent structures of recent times the cause which led to the conception of a suspension bridge for the Firth of Forth.—*Engineering.*

MILLING QUESTIONS AND ANSWERS.

1. How many machines ought the wheat to pass through before grinding? A. The wheat should be thoroughly cleaned, and if one machine could accomplish that result one would be sufficient. The grain should go through a brush machine before being ground.

2. Can the wheat be cleaned so that no fuzz will remain on the end of the berry? A. The grain not only can be cleaned in such a manner that no fuzz will remain on the ends of the berry, but should always be so cleaned. There are various devices for effecting this, but a good scourer and brush ought to thoroughly remove all hairs and foreign substances.

3. Which is the best kind of millstone—old or new stock, and why? A. The old stock is considered best, as it is more porous than the new stock, but there is very little of that stock left, and old stock burrs are much dearer than the new in consequence. The new stock is not so even in texture and temper, and it is therefore more difficult to keep the burrs in face.

4. What size is the best for a wheat stone? A. Many millers consider a 3-foot stone, well made and backed, large enough. A 40-inch stone would, however, come nearer to the size.

5. Is a cockhead or stiff spindle the best, and can a stiff spindle be kept the longest in true face? A. Mr. Gent thinks that a stiff spindle or stiff connection is the best, and gives some good reasons, but any miller who has two runs of burrs in his mill can satisfy himself as to which is best by trying both.

6. Is a horizontal or vertical mill best? A. The horizontal mill is considered best by most millers.

7. Which is the best dress to clean the bran? A. There are over two hundred different kinds of dress in use, each having its advocate.

8. What is the proper depth for the furrows when an inch draught is given, and what when two inches to the foot are given? A. The depth most generally given furrows is one-fourth of an inch at the eye and three-sixteenths at the skirt of the stone. Two inches draught is entirely too much.

9. Which is the best face tester? A. The best face tester is a good staff.

10. What is the best way to test a driver that has no boxes to drive against? A. We can't imagine such a driver.

11. What is the best shape for a cockhead so as to keep the stone in true balance, and how to make it so? A. The cockhead should be rounded at the top.

12. How should the rynd be put in a stone so as to be in true grip? A. Cut the "gains" wide enough and have the depth even, and the rynd will then catch a true grip.

13. What is the true principle on which a millstone works? A. Be more explicit.

14. In what particular way should open and close stones be respectively dressed so as to make the least specks possible, and the whitest flour? A. This is answered in 7. A porous stone does not need so many furrows as close new stock stones. Otherwise, by having them in true face, with smooth furrows of an even depth, and if you attend to them properly you will make good flour. The bolts have got something to do with specks, you know.

15. How ought the bolt be fixed to make the clearest flour for one run of burrs, and would there be anything made to have two cloths on one reel, so as to keep the middlings and bran in the inside cloth, and would the flour be clearer? A. It would be better to have two reels than two cloths on one.

16. Is there any disadvantage to return the flour with the meal? A. Yes.

17. Should not a bolt be run in such a way that the chop or meal would not drop on the other side of the shaft, but keep on or fall on the side of the shaft where it goes up? Has it not a chance to strike specks through the cloth by falling? A. Yes; we should prefer to have the meal slide on the bolt, as specks do escape by the way you mention.

18. How full ought a bolt be to do the best work? A. That is for the miller to find out by watching the bolt. To answer this question you should know the size of reel, velocity, number of cloths, etc. You will soon know by your bran if you put too much through your bolts, and you will know by your flour if you put too little.

19. If a perfectly clear flour was made without a speck and without grinding warmer than 90°, would there be any difference between that flour and "new process" flour? A. There would. It would not be new process flour.

20. I think that by more bolting capacity and finer numbers of cloths, and without dashing inside of the bolt so much, a better flour could be made in many mills with only one purifier to one run of burrs. How is this? A. That's the correct view.

21. By keeping the stones in perfect face, the furrows all alike in depth, and grinding slow with a light power and feed, and low, so as to clean the bran, and in the hands of a miller who knows just how the flour should be to give satisfaction, I think the new process could be reached and the flour would be as good as new process flour with half the machinery. If not, I would like an explanation. Pallet, in his work on milling, says that it is not the fineness, but the heat that kills the flour. Now, I think that if a stone is in perfect order, wheat can be ground at less than 90° Fahr. A. There can be as good flour made as new process flour, and your idea in that respect is correct.

22. Cannot middlings be purified on a reel if it is kept expressly for that purpose, so as to take only a portion from the head which is clear, and return the rest if the reel is properly managed? I think that it can be done with a movable bridge-tree and sufficient slides to return middlings with very little waste. A. Middlings are purified better by purifiers made for that purpose.

23. How much winter wheat does it take to make a barrel of straight grade flour? A. It takes about four and a half bushels to make a barrel of flour by the old method of grinding, but a good deal depends on the wheat.

I don't need ask about balancing burrs, as I understand it thoroughly. The following is my way: I first turn off the back of the stone. There must be two boards between the burrs to hold them steady. The boards are nailed to the floor. Then put a rest on the top of the runner and turn off the back; then put the runner in standing balance; then run the burrs at grinding speed, find the light side with a pencil, and put weights there until balanced.—*W. H. R., in The Millers' Journal.*

RAPID DRY PLATES.

By H. W. BEVAN.

So much has been written and said about gelatine emulsion plates of late, I fear you must be almost tired of receiving communications on that subject; but knowing that it is only in its infancy, I venture to give a few practical details of the results which have proved most successful in my hands.

After three months' experimenting, the formula I am about to give is with me the most rapid, as the plates prepared are certainly much quicker than the commercial ones I have tried since last summer. I can obtain results at this time of the year which were impossible for me to to get during the bright summer months with those plates.

Most of the commercial plates are called instantaneous, and, no doubt, working under some circumstances, instantaneous results may be secured, viz., out-door scenes, such as boating, cricketing, and movable objects, can be very well obtained; but can this be done in the studio? Of course, for such pictures a drop shutter is essential.

I have the most rapid lenses and other appliances it is possible to get, and with the instantaneous plates, as advertised, I have not succeeded in getting anything like successful pictures of children, dogs, etc., whilst walking about the studio.

It is, I think, very desirable at times to take children in motion, for I find there are many such that will not be posed—these are usually called pets by their mammas. Many times ladies bring their children to my studio, and state that the only way they can be taken is while playing about. This has been my object in finding out the most rapid method of taking them. My formula for preparing the plates I will now briefly describe. For six ounces of emulsion take:

Ammonium bromide	40 grains.
Fine cut gelatine	120 "

Place these in a vessel, and cover with 10 drachms of distilled water; now take 60 grains of silver, dissolve in 6 drachms of distilled water; place both liquids into warm water, so that they become both the same temperature, say, from 90° to 130° Fahr.; after standing a few minutes mix in the usual way; now add 30 minims of ammonia fort. Shake well after this; let it stand in water for about one hour, keeping it in the same heat; take one-half of the emulsion, place it in a vessel that will stand heat, gradually raise the temperature until boiling; let it boil slowly for ten minutes, after this take it from the water, and let it cool down to about the same temperature as the other half left. The whole of the emulsion can then be washed; after washing, place again into warm water, add 2 drachms of pure alcohol (if methylated spirits be used, 1 ounce); make up the six ounces with warm distilled water. The emulsion is now ready for use; if the liquid be very thin, or too transparent on pouring it on the plate, a little more gelatine may be added. I find no drawback from raising one-half of the emulsion to boiling heat. I think frilling will arise from various causes with all plates. These are not subject to frilling more than the commercial ones I have tried.

Many people say that it is essential to dry the plates quickly if you want them sensitive. For my part I have never found that it makes the slightest difference as to quickness whether they are dried spontaneously or artificially. I frequently coat and let them stand in a room at about 50° for five or six hours, and then finish drying close to some hot water pipes, which would be about 90°, and on developing there is not the slightest difference in the parts dried by different heat; but if a plate is dried off in three or four hours, it is much more liable to frill than one that has been ten to twelve hours drying. A very good plan for drying is to have a small cupboard in the darkest part of the dark room with a little ventilation top and bottom. Plates will dry in such a closet in from twelve to twenty-four hours. The developer I use is as follows:

Ammonia bromide	30 grains.
Strong liquid ammonia	1 drachm.
Water	5 ounces.
Pyrogallic acid	3 grains.
Water	1 ounce.

Add one ounce of the former to every ounce of the latter. On developing, if the pictures come out very rapidly, the plate can be washed and finished with a developer containing a greater restrainer. If frilling sets in before the development is fully completed, a small quantity of methylated spirits, or two or three grains of chrome alum (which must be kept dissolved ready for use) may be added. This has been a sure remedy as far as my experience goes with the plates just described. If intensification is required, they will readily intensify by the formula kindly given by Mr. Edwards in your journal.

I inclose a few specimens which will give you a little idea of the very great sensitiveness of these plates. The child in the swing was taken while in full motion. A Dallmeyer No. 2 C lens was used, and a guillotine drop shutter fitted inside the camera with an electric catch. This, I find, is very convenient, for I can stand quite close to my sitters, and yet be taking the portrait. I find that drop-shutter pictures can be obtained in the studio with some dry plates, but simply having a drop-shutter will not obtain perfect pictures while the sitters are in motion; but a diaphragm with a long slot cut across, the size made according to the quickness of the motion. This diaphragm must be placed in front or behind the shutter which falls. This, of course, decreases the exposure, and it is only under very favorable circumstances good results in the studio can be obtained. The picture of the little girl watering fern was taken on a dull day. This was exposed with a full open drop shutter. The portrait of lady was taken with a ten-inch focus lens, and with a shutter invented by Mr. Alexander Cowen, which will open and close as quickly as you can open and shut your hand.—*Photo. News.*

ON THE INFLUENCE OF ELECTRIC LIGHT UPON VEGETATION, AND ON CERTAIN PHYSICAL PRINCIPLES INVOLVED.*

THE vast development of vegetation proves that dissociation is accomplished freely within the leaf cells of plants, in which both water and carbonic acid are broken up in order that chlorophyl, starch, and cellulose may be formed. It is well known that this reaction depends upon solar radiation; but the question may fairly be asked whether it is confined to that agency, or whether other sources of light and heat which, in common with the sun, exceed the temperature of dissociation, may not be called into requisition in order to continue the action of growth, when that great luminary has set or is hidden behind clouds?

About two years ago I mentioned to Sir Joseph Hooker, then President of the Royal Society, that I thought the electric arc might be found sufficiently powerful to promote vegetation, and that I should be willing to undertake some experiments on the subject if he could give me any hope of confirmative results. Sir Joseph Hooker gave me sufficient encouragement to induce me to follow up the subject, and I have since that time gradually matured a plan for conducting the experiment.

The apparatus which has been put up at Sherwood consists—1. Of a vertical Siemens dynamo-machine, weighing 50 kilos, with a wire resistance of 0·717 unit on the electro-magnets. This machine makes 1,000 revolutions a minute; it takes 2 horse-power to drive it, and develops a current of 25 to 27 webers of an intensity of 70 volts. 2. A regulator or lamp constructed for continuous currents, with two carbon electrodes of 12 millims. and 10 millims. diameter respectively. The light produced is equal to 1,400 candles measured photometrically. 3. A motor, which at present is a 3 horse-power Otto gas-engine, but which it is intended to supersede by a turbine to be worked by a natural supply of water, at a distance of about half a mile from the house.

My object in making these experiments was to ascertain whether electric light exercised any decided effect upon the growth of plants. For this purpose I placed the regulator in a lamp with a metallic reflector, in the open air, about two meters above the glass of a sunk melon house. A considerable number of pots were provided, sown, and planted with quick-growing seeds and plants, such as mustard, carrots, swedes, beans, cucumbers, and melons. The plants could then be brought at suitable intervals under the influence of daylight and electric light without moving them, both falling upon them approximately at the same angle. The pots were divided into four groups.

1. One pot of each group was kept entirely in the dark.
2. One was exposed to the influence of the electric light only.
3. One was exposed to the influence of daylight only.
4. One was exposed successively to both day and electric light.

The electric light was supplied for six hours, from 5 to 11 each evening, all the plants being left in darkness during the remainder of the night.

In all cases the differences of effect were unmistakable. The plants kept in the dark were pale yellow, thin in the stalk, and soon died. Those exposed to electric light only showed a light-green leaf, and had sufficient vigor to survive. Those exposed to daylight only were of a darker green and greater vigor. Those exposed to both sources of light showed a decided superiority in vigor over all the others, and the green of the leaf was of a dark rich hue.

It must be remembered that, in this contest of electric against solar light the time of exposure was in favor of the latter in the proportion of nearly two to one; but all allowance made, daylight appeared to be about twice as effective as electric light. It was evident, however, that the electric light was not well placed for giving out its power advantageously. The nights being cold, and the plants under experiment for the most part of a character to require a hot, moist atmosphere, the glass was covered very thickly with moisture, which greatly obstructed the action of the light, besides which the electric light had to pass through the glass of its own lamp.† Notwithstanding these drawbacks, electric light was clearly sufficiently powerful to form chlorophyl and its derivatives in the plants.

These preliminary trials go to prove that electric light can be utilized in aid of solar light by placing it over greenhouses, but the loss of effect in such cases must be considerable. I, therefore, directed my observations, in the next place, to the effect of electric light upon plants when both were placed in the same apartment. The plants under experiment were divided into three groups: one group was exposed to daylight alone; a second similar group was exposed to electric light during eleven hours of the night, and were kept in the dark chamber during the day time; and the third similar group was exposed to eleven hours' day and eleven hours' electric light.

These experiments were continued during four days and nights consecutively, and the results observed are of a very striking and decisive character as regards the behavior of such quick-growing plants as mustard, carrots, etc. The plants that had been exposed to daylight alone (comprising a fair proportion of sunlight) presented their usually healthy green appearance; those exposed to electric light alone were, in most instances, of a somewhat lighter, but in one instance of a somewhat darker hue than those exposed to daylight; and all the plants that had the double benefit of day and electric light far surpassed the others in darkness of green and vigorous appearance generally. A pot of tulip buds was placed in this electric stove, and the flowers were observed to open completely after two hours' exposure.

Although the access of stove heat was virtually stopped, the temperature of the house was maintained throughout the night at 72° F., proving that the electric lamp furnished not only a supply of effective light, but of stove heat also. No hurtful effect was, moreover, observed on the plants from the want of ventilation; and it would appear probable that the supply of pure carbonic acid resulting from the complete combustion of the carbonic electrodes at high temperature, and under the influence of an excess of oxygen, sufficed to sustain their vital functions. If the nitrogenous compounds which Prof. Dewar has shown to be developed in the electric arc were produced in large quantities, injurious effects upon the plants must undoubtedly ensue; but it can be shown that

* Abstract of a paper read at the Royal Society on March 4, by C. William Siemens, D.C.L., F.R.S.

† Prof. Stokes has shown, in 1857, that the electric arc is particularly rich in highly refrangible invisible rays, a circumstance which seems to point to a great loss on passing those rays through glass.

in a well-conditioned electric lamp, with a free circulation of air round the carbon electrodes, the amount of these products is exceedingly small and of a different nature than is produced in a confined space.

These experiments are not only instructive in proving the sufficiency of electric light alone to promote vegetation, but they also go to prove the important fact that diurnal repose is not necessary for the life of plants, although the duration of the experiments is too limited perhaps to furnish that proof in an absolute manner. It may, however, be argued from analogy that such repose is not necessary, seeing that crops grow and ripen in a wonderfully short space of time in the northern regions of Sweden and Norway and Finland, where the summer does not exceed two months, during which period the sun scarcely sets.

The next step in the course of these experiments was to remove the electric lamp into a palm house constructed of framed glass, which was 28 ft. 3 in. long, 14 ft. 6 in. wide, and averaging 14 ft. 6 in. (8·62m. ×14·42m. ×4·42) in height. In the center of this house a banana palm and a few other small palm trees are planted, the sides of the house all round being occupied with a considerable variety of flowering plants. The electric light was fixed as high as practicable at the south corner of the house in order that its rays might fall upon the plants from a direction and at an angle coincident with those of the sun during the middle of the day. The temperature of the house was maintained at 65° F., and the electric lamp was kept alight from 5 P.M. to 6 A.M., for one week, from February 18 to February 24, excepting Sunday night. The time was hardly sufficient to produce very striking effects, but all the plants continued to present a healthy appearance.

Of three Alicante vines the one nearest the electric light made most progress; and the same could be said of the nectarines and roses. It was observed that other plants, such as geraniums, continued to exhibit a vigorous appearance notwithstanding the heat of the place. This experiment is of importance in showing that the electric light, if put into conservatories or greenhouses, does not injure the plants but rather improves their appearance and growth. The leaves assume a darker and more vigorous appearance, and it seems that the coloring of the flowers becomes more vivid; but a further period of time is necessary to establish this observation absolutely.

I decided to try the effect of electric light as a means of promoting growth in the open air and under glass at the same time.

The regulator was put back into its first position, two meters above the ground, with a sunken melon house on one side, and a sunken house containing roses, lilies, strawberries, and a variety of other plants on the other. The space of ground between these, about one meter broad and seven meters long, was covered with boxes sown with early vegetables, including mustard, peas, beans, and potatoes; and in order to prevent cold winds from injuring the plants, low protecting walls were put up across the openings of the passage between the two houses.

Some weeks must elapse before any absolute results can be given, but growth is evidently promoted under all these various circumstances. In order to test this clearly, a portion of the plants both under glass and in the open air are shaded from the electric light without removing them from their position of equal temperature, and exposed to solar light during daytime. The effect upon the flowering plants is very striking, electric light being apparently more efficacious to bring them on than daylight.

Although the amount of heat given off from the electric arc is not great, compared with a gas flame (giving off its products of combustion), yet the rays of intense heat of the arc counteract that loss of heat by radiation from the leaves into space, which, during a clear night, causes hoar frost. For this reason I expect that electric light may be usefully employed in front of fruit walls, in orchards, and in kitchen gardens, to save the fruit bud at the time of setting; and in this application electric light will probably be found a useful agent not only to promote rapid growth, but to insure a better yield of fruit.

The experiments seem to lead to the following conclusions:

1. That electric light is efficacious in producing chlorophyl in the leaves of plants and in promoting growth.

2. That an electric center of light equal to 1,400 candles, placed at a distance of two meters from growing plants, appeared to be equal in effect to average daylight at this season of the year, but that more economical effects can be attained by more powerful light centers.

3. That the carbonic acid and nitrogenous compounds generated in diminutive quantities in the electric arc produce no sensible deleterious effects upon plants inclosed in the same space.

4. That plants do not appear to require a period of rest during the twenty-four hours of the day, but make increased and vigorous progress if subjected during daytime to sunlight, and during the night to electric light.

5. That the radiation of heat from powerful electric arcs can be made available to counteract the effect of night frost, and is likely to promote the setting and ripening of fruit in the open air.

6. That while under the influence of electric light plants can sustain increased stove heat without collapsing, a circumstance favorable to forcing by electric light.

7. That the expense of electro-horticulture depends mainly upon the cost of mechanical energy, and is very moderate where natural forces of such energy, such as waterfalls, can be made available.

Since writing the above my attention has been drawn to an article in *Nature*, vol. xxi., p. 311, giving interesting observations by Dr. Schübeler, of Christiania, on "The Effect of Uninterrupted Sunlight on Plants in the Arctic Regions." These observations fully confirm the conclusion indicated by my experiments with electric light. Not only are plants able to grow continuously, according to Dr. Schübeler, but when under the influence of continuous light, they develop more brilliant flowers and larger and more aromatic fruit than under the alternating influence of light and darkness, whereas the formation of sugar appears to be dependent chiefly upon temperature.

It would follow from these observations that, with the aid of stoves and electric light, fruit, excelling both in sweetness and aroma, and flowers of great brightness, may be grown without solar aid. Dr. Schübeler mentions that, in removing an acacia plant from the dark and placing it under the influence of the Arctic midnight sun, the leaves opened slowly, and it is interesting to observe that the same effect took place when an *Acacia lophantha* was placed (in the open air) under the influence of my midnight lamp.

PICTET'S PROPOSAL TO DISSOCIATE THE METALLOID ELEMENTS.

THE task set before me is to expound in as simple and intelligible language as possible the remarkable train of reasoning which has led M. Raoul Pictet, of Geneva, to the conclusion that the so-called metalloids are really not elementary bodies at all, but capable of dissociation into simpler forms. During the last two years M. Pictet has published several important memoirs upon different branches of thermo-dynamics, and has, as is well known, in his researches on the liquefaction of oxygen and of hydrogen, shown the fruitfulness of the ideas which have thus occupied him. He is at the present moment engaged upon a large volume entitled "Synthèse de la Chaleur," a work in which it is sought to deduce all the known laws of heat from the general principles of theoretical mechanics, by finding true mathematical definitions for the quantities which hitherto have been usually expressed as simple experimental matters. Thus the terms "temperature," "specific heat," "latent heat," etc., are capable of exact definition in a manner which enables the relations between them to be investigated analytically. These relations thus investigated are found by M. Pictet to be capable of experimental verification, and the complete accordance of deduced theory with observed fact justifies him in giving the name of *Synthesis of Heat* to this new advance in thermo-dynamics.

To understand aright the views of M. Pictet with respect to the possible dissociation of the metalloids, we must notice briefly the fundamental points of his theory of heat. If the atoms of a body are in absolute rest and equilibrium, their temperature will be at *absolute zero*. If, however, kinetic energy is imparted to these atoms and they are set vibrating, the *temperature* of the body will be represented by the *mean amplitude* of the oscillations, and the total *quantity of heat* in the body will be the quantity of energy thus imparted.

Now the great decomposing force in nature is heat. It is heat which changes solids to liquids, liquids to vapors. Heat breaks up chemically combined substances and reduces them to simpler forms. It is quite certain that the limits of the power of the chemist to decompose the substances that pass through his hands are those which correspond to the temperatures which he can produce in his laboratory. We shall explain at a later portion of this article how this comes to be the case. Yet there are in nature temperatures far more elevated than the highest artificial temperature. To take the most striking example, the surface of the sun must be enormously hotter than even the hottest of the electric arcs, in which even the most infusible of metals is vaporized. We know this upon evidence which accumulates every day, and of which the most important is that afforded by the spectroscope. The researches of Kirchhoff and J. W. Draper, and the later works of Cornu, Mascart, and Lockyer, establish incontestably that the radiation emitted by a glowing substance varies with the temperature of the substance, and that at higher temperatures new rays of shorter wave length and more rapid oscillation appear, while the intensity of all the emitted rays is also greater. The solar spectrum is much more rich in violet and ultra-violet rays at the more refrangible end of the scale, than the spectrum of any artificially heated substance. The irresistible conclusion is that its temperature is far higher.

But the spectrum of the sun when scrutinized with the most elaborate skill and knowledge reveals another very striking circumstance. A large number of the substances regarded by the chemist as *elements* have now been recognized by the characteristic absorption lines of their spectra as existing in the heated matters surrounding the sun. The researches of Mr. Lockyer show that nearly forty of the metals are thus to be detected. But *not a single metalloid* is thus discoverable. Indeed, so marked is their absence that the presence of hydrogen in such great abundance is held by no less an authority than Mr. Dumas, to be a convincing proof that hydrogen is a metal and not a metalloid. It is true that Mr. Henry Draper, of New York, has announced the discovery of *bright* lines corresponding to oxygen amongst the dark absorption lines of the solar spectrum, but it is far from certain whether the coincidence he has pointed out is real or apparent only, and all other evidence points to an adverse conclusion.

Putting together these two capital facts of solar spectroscopy, the irresistible inference is that the surface of the sun is too hot for metalloids to exist there; or, in other words, *its temperature is higher than the temperature of the dissociation points of the metalloids.* This term dissociation point is justified by analogy with the terms boiling point and melting point, with which we are familiar, and with which we associate the notion of definite temperatures.

Let us examine, following M. Pictet's fundamental principles, how far this analogy can be followed out and justified. Those fundamental principles are that in hot bodies the molecules are swinging to and fro about positions of equilibrium; that "heat" *is* the energy of these molecular vibrations; and that the "temperature" of the body *is* the mean amplitude of the vibrations. If more energy is imparted to a solid, the more energetically will its particles oscillate, the longer will be the mean amplitude of their oscillations, and the higher the temperature. If we allow that the gravitation law of attraction, namely, that the attraction between two masses varies inversely as the square of the distance between them, holds good not only on the grandest scale, but also on the most minute, we must admit that the force acting on a vibrating particle at the furthest limits of its swing, and tending to attract it back, will be relatively weak as the amplitude of the swing is great. Hence too long a vibration may carry the particle right beyond the field of molecular attraction; and the particle will not return, but will carry off with it in the form of potential energy part of the heat furnished to the body. The sum of these small quantities of potential energy which must necessarily disappear from the body during its change of state from the solid to the liquid condition constitute that which we usually term "latent heat."

Now consider a solid body at the absolute zero of temperature to which new quantities of heat are continuously imparted. What will be the successive changes to be observed? At first the temperature of the body will rise proportionately to the quantity of heat imparted to it. When the vibrations of the particles have attained a certain amplitude, fusion will take place, not all at once but gradually, each molecule passing away from the attraction of its neighbors, as soon as its vibration is sufficiently energetic. Each solid particle will thus be split up into two or more liquid molecules exactly resembling each other. Every one of these molecules will require potential energy, hence during the entire process of liquefaction, the whole of the heat imparted will be employed in producing the change of state; so that the temperature will be stationary in spite of the continual addition of heat. But when the whole substance has melted, the temperature will again rise up to a certain point determined by the commencement of ebullition, a point which will vary with the conditions of external pressure.

This second change of state arises from a further splitting up of the molecules into two or more portions each, every separated portion again carrying off with it a further quantity of potential energy, the "latent heat" of vaporization. If the gaseous molecules thus produced receive still further quantities of heat, the temperature will go on rising until another point is reached, corresponding to a first chemical *dissociation*, when, as the lengths of oscillations become excessive, the separate atoms are successively thrown apart. This process, like those of liquefaction and vaporization, will be accompanied by the absorption of heat. The extent to which energy must be furnished in order thus to produce chemical separation, will be proportional to the chemical affinity of the separated atoms; and if the body consists of several chemical constituents it is probable that some of these will be dissociated at lower temperatures and some at higher. The limits of dissociation will have been reached when the body has been separated into its ultimate particles or true elements.

The striking feature of this series of changes is that while the addition of quantities of heat goes on continuously, the rise of temperature is discontinuous, having several stationary points in the range between the absolute zero and the highest possible temperature; each fresh stationary point corresponding to a change of state, or a decomposition of the particles into simpler forms.

Suppose next that we could reverse the order of operations, and could abstract the heat continuously from the dissociated bodies, we might expect to find the same series of changes occurring in the inverse order. But this expectation would not be realized, for reasons which are not difficult to find. In the two changes of state which are of a nature usually termed *physical changes*, namely, liquefaction and vaporization, the result of the splitting up is to produce particles all of the same kind. In a liquid—water, for example—all the liquid particles are water. In a vapor—steam, for example—the particles are all particles of steam. But in the case of *dissociation*, which is a *chemical* change of state, the result of the splitting up is to produce particles not all of the same kind. Thus, if steam is passed through a white hot platinum tube, the dissociated matters are of two kinds, oxygen particles and hydrogen particles. In the changes denominated "physical," which produce homogeneous particles, the recombination does not depend on the relative *positions* of the constituents, but only on *pressure* and *temperature*. In the changes denominated "chemical," which, as we have seen, produce heterogeneous particles, the recombination of the constituents depends on their relative *positions* and on the way in which they have to be grouped in the compound, as well as on pressure and temperature. This most important distinction must not be overlooked.

Again, the dissociated chemical atoms carry away with them in a potential form the heat which has disappeared during the process of dissociation, exactly as a liquid carries in a potential form the "latent heat" which disappeared during the process of liquefaction. If we collect the separated chemical constituents—the oxygen and hydrogen for example—and make them recombine, they will evolve this potential energy and the heat will reappear. The limit of temperature, therefore, which can possibly be reached by the combustion or chemical combination of any bodies is precisely the temperature of the dissociation point of the substances formed. Hence there is obviously, as we remarked at the outset, a limit to the power of the chemist to dissociate bodies; a limit determined simply by the temperatures he can artificially produce.

It will be remarked, however, that we have in the electric current a means of obtaining many decompositions which without its aid would have been unknown to us. We may even assert upon the certain evidence of the spectroscope, that the temperatures attained by the electric spark are far higher than those of any known combustion. Nevertheless there are here also limits which cannot be passed. If in the circuit of the most powerful battery we interpose a conductor of considerable resistance its temperature will rise; and, if the conductor be reduced in thickness to augment its resistance, will continue to rise until the conductor itself is either liquefied, volatilized, or dissociated, when of necessity a practical limit is reached in the entire stoppage of the current. Again, with the discharges from induction coils and Leyden jars, which take place even across gases, there must be a limit, determined by the absorption of energy by the very molecules which are concerned in the discharge, and whose resistance to the electrical action will increase with their temperature. It is a point which may admit of some further discussion. But, on the whole, one is led to the conclusion that the dissociations we have shown to be theoretically possible are in a very large number of cases absolutely beyond the practical limits of experimental achievement.

One course yet remains open. We have not hitherto considered the connection between temperature and radiation in its bearings upon this question. It appears that every temperature, as defined above, corresponds to a definite kind of radiation. Every calorific oscillation of a particular rate is then associated with the propagation of a wave of disturbance in the surrounding ether; this wave having a particular frequency, or what is the same thing, a particular wave-length. When these calorific waves in passing through space meet a body, they tend to set its particles vibrating; and, what is more important, tend to set them vibrating in unison with the original vibrations of the radiating source. If it were not that the receiving body were subjected to external influences, it would acquire little by little exactly the same temperature as the body from which the radiations were emitted. In other words, thermic equilibrium would be established between the two, quite irrespective of the distance between them.

We know that the rays of the sun traverse space without any diminution in their frequency or wave-length. It follows, therefore, that *the sun's rays are able to raise to a temperature equal to that of the sun's surface any body on the surface of the earth on which they can be concentrated*, provided only such a body could be preserved from losing heat by conduction or radiation. Although a certain quantity of the solar radiation is arrested by absorption in the imperfectly transparent atmosphere surrounding the earth, measurements made at places so widely apart as Cairo, Paris, and St. Petersburg, agree in showing almost identical values for the amount of heat received from the sun, and which is about twelve calories per square meter per minute.

Now on the supposition that all the metalloids, with the exception, perhaps, of oxygen, are dissociated in the sun, thermal equilibrium, if thus experimentally obtained, ought to effect the dissociation of them upon our globe also.

M. Pictet, therefore, proposes that an enormous parabolic

mirror should be constructed, in the focus of which the sun's rays should be concentrated upon the various metalloids which it is sought to decompose. All the data for calculating the requisite size of the mirror are known to a certain approximative value, with one exception. We know the quantitative intensity of solar radiation, and the reflecting power of polished metals, and hence can calculate how many units of heat a mirror of given size will hurl into its focus per minute. *We do not know* how much heat must be furnished to a given weight of any one of the hitherto undecomposed metalloids to dissociate it, but we are quite certain that this quantity must be much greater than that produced by the combustion of an equal weight of hydrogen and oxygen.

Assuming that to dissociate bromine required *a hundred times* as much heat (at the temperature of its dissociation-point) as water vapor requires (at *its* dissociation point) to split it up, M. Pictet calculates that a single gramme of bromine must have 350 calories expended upon it to resolve it into its elements. Further calculation leads him to consider that to dissociate one gramme of bromine per minute, would require that the solar rays should be concentrated by a mirror of *at least* 35 square meters of surface, measured normally to the rays, or of about ten meters aperture. It would, he thinks, be best constructed in separate pieces of about a square meter in area, each ground and polished to a true curve and mounted in a special frame. The depth of the mirror should be equal to half its aperture, bringing the focus into the plane of the rim. At the focus would be a special *solar chamber*, or crucible, constructed of lime or zircon, or other refractory substance, into which the vapors to be operated upon would be led. To avoid loss of heat it would be kept hot from without by oxyhydrogen flames. The whole apparatus ought not, he thinks, to weigh as much as two tons. To catch and retain the dissociated substances, and to prevent their immediate recombination, he proposes to aspirate the vapors of the chamber through metal tubes containing metallic gauze, and cooled from without to a temperature perhaps as low as —50° by intense artificial refrigeration. The rapid cooling thus produced should hinder at least a considerable proportion of the constituents from recombining as fast as they were liberated from each other in the solar chamber.

There is much that is suggestive in the proposals of M. Pictet; so much, indeed, that any attempt at criticism or comment would outrun the limits of this article, which is, therefore, simply devoted to the exposition of M. Pictet's ideas in phrases as nearly identical as possible with those in which he has himself expressed them.—*S. P. T., in Nature.*

PHYSICS WITHOUT APPARATUS.

SOME twenty years ago, Babinet, who seemed to have the faculty of popularizing science and inciting a taste for it, published in the *Magasin Pittoresque*, under the title of "Chemistry without a Laboratory," a series of articles in which he endeavored to describe a means of repeating the fundamental experiments of this science with the aid of very elementary and cheap little pieces of apparatus. What Babinet did for chemistry, a writer in *La Nature* is beginning to do on physics in a series of articles, showing how to perform numerous instructive experiments with *almost nothing*—or, at least, with just such ordinary objects as every one has always at hand. The late M. Balard, whom science was called on to mourn a few years ago, excelled in performing chemical experiments without a laboratory. Fragments of bottles, and pieces of table utensils, and various other common things, all came handy to him in improvising apparatus to execute important work. Scheele used to operate in the same way. He was enabled to make great discoveries with very humble tools and by the aid of very small resources. Too much encouragement cannot be given young people to make them endeavor to become skillful in

FIG. 1.

the art of using apparatus, and, at a pinch, to make them for themselves.

In the present article it does not concern us to make researches, but to sketch a plan of teaching, based on experiments in physics executed without special apparatus. The majority of these experiments are of course known, and the only pretension that we make is that of having brought them together, and grouped them in order to describe them. We ought to add that we have tried and verified all of them, so that the reader may repeat them with every certainty of success.

Suppose we were addressing a young audience, and began our lecture course on physics with some ideas in regard to the pressure of the atmosphere: a glass goblet, a dish, and some water would at once serve for our first experiments. Here is a plate in which I pour some water (Fig. 1); now I set fire to a piece of paper resting on a little cork float, and immediately invert over it a goblet. What happens? The water rises in the glass. Why? Because the paper in burning absorbs a portion of the oxygen, and the volume of the confined gas having diminished, the pressure of the external air drives the liquid up into the glass. I now fill a goblet

FIG. 2.

with water up to the very edge, and I cover it with a sheet of paper, which adheres well to the edge of the glass and with the surface of the liquid. I turn the glass upside down (Fig. 2), and the sheet of paper prevents the water

FIG. 3.

from flowing out. Why? Because the paper is held in position by the pressure of the atmosphere. It sometimes happens that this experiment succeeds only after several trials on the part of the operator, so it is prudent to invert

FIG. 4.

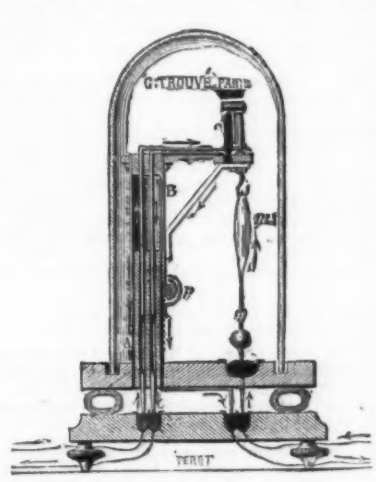
the glass over a vessel in order that the water may be caught in case of failure. Let us now add a water bottle (*carafe*) to our material. We shall thus have a substitute for an air pump, and be easily able to perform the experiment of bursting a bladder. I set some paper on fire, and while it is burning I thrust it into the bottle full of air. After the paper has been burning for a few moments, I close the aperture of the bottle with a hard boiled egg (from which I first remove the shell), and in such a way that it forms an air tight cork. The combustion of the paper creates a vacuum in the bottle, the egg is gradually pushed in by the pressure of the external air, and becomes elongated (Fig. 3). All at once it suddenly enters the bottle, and causes, as it does so, a slight noise similar to that obtained when we strike a paper bag inflated with air. This is atmospheric pressure demonstrated in a very manifest way, and at very small expense. Fig. 4 represents the diving bell experiment, and is so simple that it is hardly worth while to describe it. Two or three flies have been introduced under the glass, and, by flying about, prove that they find themselves much at ease in the compressed space. Should we desire to carry our lesson in regard to the pressure of the air still further, it would be necessary to add to our stock of apparatus a corked glass tube and a little mercury. Thus we should have the necessary elements for trying Torricelli's experiments, and for readily explaining the theory of the barometer.

A plaything well known by boys under the name of a "sucker," might again prove the subject of numerous dissertations on the vacuum and pressure of the air. As well known, this object is formed of a circle of wet leather, to the center of which is attached a cord. When placed on the sidewalk it is pressed down flat with the foot. When we try to lift it by the cord, it acts like a cupping glass and holds fast to the pavement with such tenacity that it is difficult to remove it. Such an apparatus, as may be seen, acts as a substitute for the Magdeburg hemispheres. There is no branch of physics that may not be illustrated thus by objects accessible to everybody. But this we promise to do our best to demonstrate in the sequel. We do not desire to prolong our description of experiments of this nature at present, but we will reserve some that are a little less known for a future article.

(To be continued.)

MICROPHONE FOR THE STUDY OF MUSCULAR CONTRACTION.

MESSRS. G. TROUVÉ AND H. DE BOYER have recently constructed a microphone which is designed to be used in the study of muscular contraction. The apparatus, which is figured herewith, really constitutes a microphonic chamber, in which physiological or other experiments may be performed under determinate conditions, and be modified at the pleasure of the operator. As will be seen, it consists essentially of two electric circuits insulated one from the other. On the occasion of the experiments in regard to muscular physiology which Messrs. Trouvé and Boyer performed before the Biological Society, Jan. 17, 1880, one the circuits was used as an excitant of the muscle, while the other necessarily communicated with the telephone. The contacts of these circuits are all mercurial, and the style of microphone used in these preliminary essays was the vertical. Having completely freed the microphone from all other influences than those of mechanical shocks, Messrs. Trouvé and Boyer find that the work of the muscle does not give rise to such



shocks, and that it is perfect, then, when the muscle is free to contract without effort and resistance. Certain new arrangements will permit of experiments being made in regard to the molecular vibrations which may take place in the muscle. The following is an explanation of the accompanying cut:

A, Tube fixed to the upper standard.

B, Tube supporting the arm and microphone, C. This tube is held by friction on the tube, A, which is raised or lowered at will by means of the rack and pinion, *p*.

C, A very sensitive microphone.

m, Muscle under experiment.

Suspended from its extremity there is a small ball provided with a hook and a platinum point which dips into a mercury cup.

The arrows to the left of the figure denote the direction of the microphonic current; and those to the right, the direction of the exciting current.

AN ELECTRICAL TELEMETER.

THIS new telemeter, which we find figured and described in *La Lumière Electrique*, gives a very elegant solution of the following problem: To determine, by a simple reading, accurately, quickly, and at any moment, the distance of an inaccessible, distant, and moving object. The principle of the apparatus is shown in Figure 1. From two points of observation, O O', situated at a known distance (say 1,200 meters) apart, we regard the point, N, whose distance from the point, O, we wish to ascertain. If, by any process whatever, we cause a straight needle, A*a*, pivoting around the point, A, to remain always parallel to the axis of a telescope, O' L', of the point of observation, O, we will form two similar triangles, OA*n* and OO'N. If the distance, OA, is 1.20 meters, the side, OO', being 1,200 meters, it will follow that every *millimeter* on the side, O*n*, will correspond with a length of *one meter* on the side, ON, and, that on reading

the distance, On, expressed in millimeters on a graduated scale, R, this number will be the expression *in meters* of the distance, ON. The rôle of electricity in this telemeter of M. de Tromelin is to maintain a constant parallelism between the needle, Aα, and the axis of the telescope, O'L'. The apparatus, then, is composed of two distinct parts: (1) A *manipulator*, situated at O, which has the effect of distributing electric currents dependent on the movement of the telescope, L; and (2) a *receiver*, which utilizes these currents in moving the needle, Aα. The whole forms a sort of two-wire telegraph.

THE MANIPULATOR.

This is composed of a telescope, L' (Fig. 1), carrying a

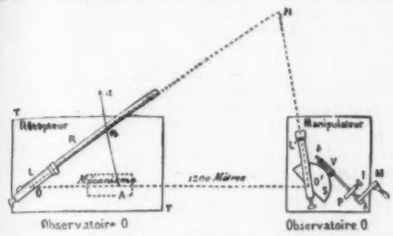


FIG. 1.—METHOD OF USING THE ELECTRIC TELEMETER.

toothed sector, S, put in motion by a tangential screw, V, fastened to a winch, M. By turning this winch in one direction or the other, the telescope is moved to the right or left, thus permitting the moving object to be followed. On the axis of the tangential screw is placed the current distributer represented in Fig. 2, and the functions of which we shall study. A wheel with eight cams is fitted on the axis of the screw; and a roller, *g*, fixed on a rod, *r*, forming a spring, keeps pressing constantly upon it. When the roller is in one of the depressions, the spring, *r*, does not touch the point, *d*, and the current, coming from the battery, F, does not pass into the wire connected with the binding-screw, B'', of the receiver. If the winch be turned from right to left, the wheel will also turn, and there will be a contact at *d*, and consequently a passage of the current every time one of the cams comes opposite the roller, *g*. For every turn of the endless screw there will be *eight* emissions of the current, the receiver will receive the electric current eight times, and the needle, Aα, will move under the influence of these currents, as we shall presently see. On the axis of the endless screw is fixed an inverter, I, con-

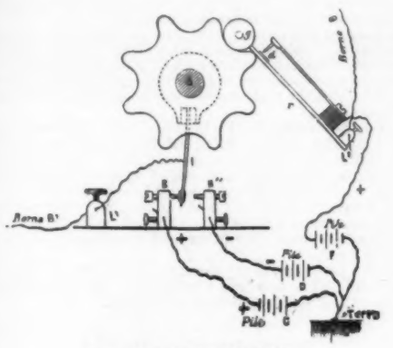


FIG. 2.—MANIPULATOR.

nected by a wire to the binding-screw, B, of the receiver. When the winch is turned from the right to the left the rod, I, touches at B, and the current that traverses this wire is *positive*, since it comes from the pile, C; but if it be turned from left to right, the inverter, moved along by friction, touches the binding screw, B'', and a *negative* current enters from the pile, D. To sum up: 1. By turning M from right to left, the wire, B^1, receives a continuous positive current, and the wire, B^2, intermittent currents, at the rate of eight for every turn of the winch. 2. By turning M from left to right, the wire, B^1, receives a continuous negative current, and the wire, B^2, intermittent currents as in the first case. 3. At rest, the wire, B^2, receives no current, and the rubber, *g*, resting between the cams, preserves its position.

THE RECEIVER.

The currents reach the binding-screws, B^1 and B^2, through two wires (Fig. 3). The receiver is composed of a clock-

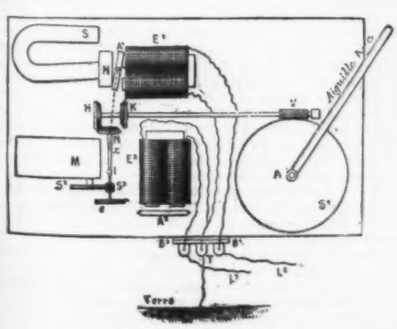


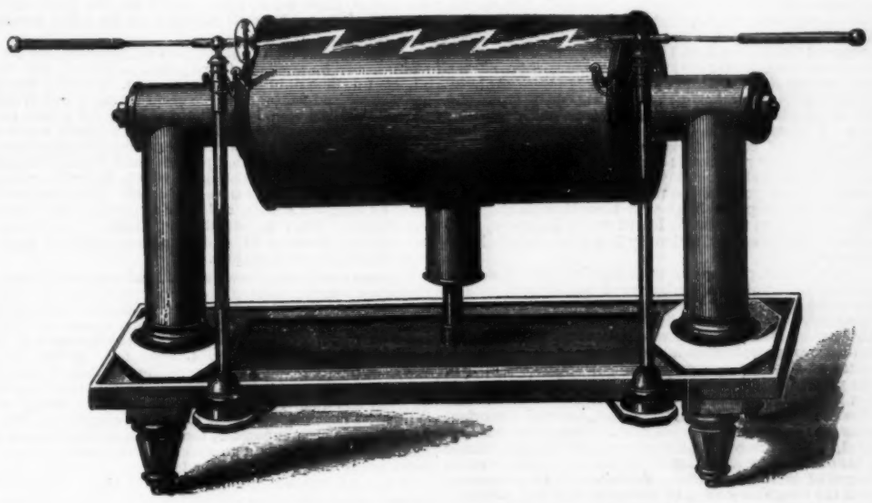
FIG. 3.—RECEIVER.

work, M, which through a series of wheels, S^1 S^2, transmits motion to a bevel wheel, N, connected with the axis of the wheels, *c* and S^3, by a Cardan joint. The current coming from B^2 traverses an electro-magnet, before which is placed an armature, A^2, which, by an arrangement omitted in the cut to avoid complication, acts on the toothed wheel, *c*, and allows the escape of *one tooth* every time that a current is produced. The wheel, *c*, and consequently the bevel wheel, N, moved by the clock-work, turns forward one tooth at a time, and *always in the same direction*, every time a current comes from the manipulator through the wire, B^2. The wire, B^1, traverses a second electro-magnet, E^1, before which is placed a polarized armature, A^1—the polarization being effected by a horse-shoe magnet, NS. This armature, according to the direction of the current traversing the electro-magnet, E^1, assumes two different positions, because of the attractions and repulsions produced by the opposite or same poles. By taking one of its two positions, the armature moves the axis, *z*, of the wheel, N, which then gears with the wheel, H (as in the cut), or conversely with the wheel, K. The result is that the motion of the screw, V, takes place in one direction or the other according as the current which traverses E^1 is positive or negative. As the screw, V, is fastened to a toothed circle, S^1, analogous to that of the manipulator, the scale, Aα, fixed on this sector, follows all its movements. By this arrangement, which is a little difficult to explain, but very ingenious, every movement of the telescope, L', of the post, O', is transmitted electrically to the scale Aα, and there is nothing to do but read off the distance on the graduated scale of the telescope, L. Every movement of the needle, Aα, corresponds to an angular displacement of 1' 52·5", so that the distance is obtained very accurately. This apparatus is destined to play an important part in the defense of passes, for it will allow of a very quick determination of the speed of a ship, and will facilitate the use of Whitehead torpedoes. It will also prove very useful to coast fortifications, which often have to aim at moving and very distant vessels. The system has been tried experimentally at Lorient, and favorably reported upon by a special commission appointed by the Minister of Naval Affairs.

LARGE INDUCTION COIL.

MR. WILLIAM SPOTTISWOOD, President of the Royal Society of London, has had constructed by Apps, the London manufacturer of physical instruments, an induction coil, which exceeds in dimensions and effects anything of the kind that has hitherto been made. The apparatus, which is figured in the *Philosophical Magazine*, and which is reproduced herewith, may be described as follows: As seen by the engraving, the bobbin is supported by two massive wooden pillars, covered with gutta-percha and paraffined at their two extremities. Besides these two supports, there is a third and middle one, the height of which can be regulated by a screw, in order to resist the flexion of the conductor are obliged to bear. Each of these sections is itself composed of flat disks, which have a thickness of about 200 layers of the wire of which they are formed. Finally, the total number of spirals of the secondary circuit amounts to 341,850. The great length of wire which is necessary is understood when it is reflected that the outside spirals are nearly 5 feet diameter. It is admitted that the spark increases rather with the number of spirals than with the length, provided good insulation be effected in all the parts. To be certain of arriving at the most satisfactory results, each disk was tried separately and with great care, and then they were again tried in series, and all the results recorded. As a highest proof, seventy Grove elements were made to act on the bobbin without in any way affecting the insulation. The condenser adopted for this coil is much smaller than might be supposed. After numerous experiments, the dimensions selected were those employed by Mr. Apps for coils designed to to give a 10-inch spark. These condensers are formed of 126 sheets of tin, ¾x1¾ inches, separated by a double thickness of varnished paper. The following are some of the results obtained with this powerful apparatus (using the first described induction system):

With five large Grove couples the spark measured 28 inches; with ten couples, 35·5 inches; and with thirty couples, 42·5 inches. In a few cases 44 inches was reached. It is important to remark that these sparks are longer than the bobbin furnishing them; and thus they very perceptibly exceed the limits that several physicists had assigned to them. As is well known, induction coils or bobbins (or *inductoriums*, as they are styled in England) give two induction currents—one at the instant the inducting circuit is closed and the other when it is opened. The first exhibits no tension, and it is the second which furnishes the sparks. With the splendid apparatus under consideration, plate glass 3 inches thick has been perforated without even using piles, which produce a maximum of effect.



LARGE INDUCTION COIL.

BALMAIN'S LUMINOUS PAINT.*

By C. W. HEATON, F.C.S.

I HAVE been invited to give this evening an account of one of those practical applications of science which have always had peculiar interest for members of this society. In doing so I shall be compelled to allude briefly to some scientific truths, familiar to many among my audience, and particularly to those who attended Mr. Preece's recent and interesting lectures.

Every one knows that a ray of white light consists of minute waves or ripples, analogous to those of water, and of the principal piece. The whole apparatus is mounted on a solid mahogany base resting on short legs. The coil may be operated with two induction circuits, either of which may be used as occasion may require. Two persons can remove one and substitute the other in a few minutes. The first of these, which is employed for the production of long sparks, and, in fact, for the majority of experiments, has a core, composed of 0·03 inch iron wires, forming altogether a cylinder 31½ feet long and 3½ inches in diameter. Its weight is over 60 pounds. The copper wire which forms the inductor is nearly 2,000 feet in length, and has a conductivity of 93 hundredths, a total resistance of 2·3 ohms, and weighs nearly 55 pounds. It is rolled around a bundle of iron wires, in 1,344 spirals, arranged in six layers, so as to form a cylinder 3½ feet long, with an outside diameter of 4¾ inches. The other system, which is designed for working with piles of greater surface, for giving short and more copious sparks, and for spectroscopic experiments, has a core of iron wire of the same diameter as the preceding, forming a cylinder 3½ feet long and 4 inches in diameter. Its weight is 90 pounds. The copper wire is the same in the first-mentioned induction circuit, but the conductor (which is 1,500 feet in length) is composed of two parallel wires. It is divided into three sections, of two layers each, and their resistances are, respectively, 0·181, 0·211, and 0·23 ohm. The length of the cylinder thus composed is 3½ feet, its diameter 5½ inches, and its weight 80 pounds.

By means of a new arrangement these three sections can be placed in a single series:

This induction coil has been employed to furnish sparks 34 inches long (in the air), with a Grove battery of ten elements, the electrodes of which were of platinum, and 3 by 6 inches in size. The secondary circuit is composed of about 1,500,000 feet of wire, forming a cylinder 38 inches long, 20 inches outside and 10 inches inside diameter. The conductivity of this wire is 94 per cent. and its total resistance 110,200 ohms. It is distributed in four sections: in the two middle ones the wire is about 0·009 of an inch in diameter, and in the two external the wire is 0·011 of an inch in one, and in the other 0·012 of an inch in diameter. The reason for using wires of greater diameter at the extremities is on account of the accumulated charge that these parts of

I shall be compelled to allude briefly to some scientific truths, familiar to many among my audience, and particularly to those who attended Mr. Preece's recent and interesting lectures.

Every one knows that a ray of white light consists of minute waves or ripples, analogous to those of water, and of various lengths. The mean length of these waves, measured from the crest of one to the crest of the next, may be taken as the fifty-thousandth of an inch. They all travel in straight lines, and all with the same velocity, a velocity which is called the velocity of light. In passing through a prism, these lines of waves are refracted or bent at different angles, and when afterward allowed to fall on the screen they are reflected back to our eyes, and a portion of them, acting on the optic nerve, produce the sensation of color. These rays are, therefore, called the visible rays. Here on the screen you see the spectrum of the white electric light.

The eye is, however, a very imperfect optical instrument, and is only sensitive to waves between certain limits of length. The real spectrum on the screen is much larger than the visible one. There is a portion beyond the red which is called the ultra red portion. The waves of this portion are too long to affect the eye, but are powerful in producing the phenomena of heat. The rays are therefore sometimes called the invisible or obscure heat rays. There is also a portion beyond the violet, produced by waves too short to affect the eye, but active in producing chemical and other effects. These rays are called the ultra violet, actinic, or chemical rays.

Many years ago Sir John Herschel observed the peculiar blue opalescence which a solution of quinine presents when held in certain lights. Brewster made further observations of the same kind; but it was not until 1852 that Prof. Stokes, of Cambridge, published the memorable research on the subject which would alone have been sufficient to render his name immortal in the history of science. Stokes suggested the name fluorescence for the phenomenon, and showed that it was due to a power which some bodies possess of absorbing light waves and emitting them again as longer waves. Quinine is peculiarly sensitive to violet and ultra violet rays. If I pass a solution of quinine through the spectrum, beginning at the red end, you will see that the fluorescence does not appear until we reach the blue portion, but continues to be visible far beyond the violet. In the ultra violet portion we have a distinct conversion of invisible actinic into visible light rays. Here is a solution of the new Magdala red made

* A lecture delivered before the Society of Arts, March 11, 1880.

from naphthalin. It appears black in all parts of the spectrum except the region of the yellow, in which it shows a magnificent red fluorescence. This experiment proves that fluorescence is not always caused by the conversion of invisible into visible waves. We now throw a beam of electric light, filtered to some extent from heat rays by passing through ammonio-sulphate of copper, on two jars of water, and throw into one a solution of quinine, and into the other an alkaline solution of the curious compound called fluorescene. You perceive in the one case a blue, and in the other an intense emerald-green fluorescence, and it is really difficult to believe that in each case the solution remains transparent. In fluorescence, then, we have generally, if not always, an increase of wave length due to the molecular action of certain substances. The waves are never shortened, and are sometimes described as suffering "degradation." The luminosity ceases as soon as the incident light is withdrawn, or, to speak more cautiously, it lasts only for a minute period of time afterward. In the case of quinine the work of converting invisible into visible rays seems to take about the five thousandth part of a second.

We come now to a closely allied, if not identical, phenomenon. Many substances are known which, having been exposed to light, continue to emit light for measurable periods of time after the luminous source is removed. This phenomenon is called phosphorescence, and it is with this that we are chiefly concerned to-night. The term phosphorescence has been applied to light emitted during the slow oxidation of phosphorus; the light of living animals, such as the glowworm and the noctiluca; the light attendant upon incipient putrefaction, animal and vegetable; the light produced by the heating of phosphorus and many other bodies; by percussion, as when sugar is struck with a hammer or rubber; and the beautiful phenomena developed in high vacua in that strange condition of matter with which Mr. Crookes' remarkable discoveries have lately made us familiar; and, lastly, we have the light which follows insolation. All these are grouped together under the general term phosphorescence, but it is with the last one that we have at present to deal.

The history of discovery in regard to this kind of phosphorescence is a somewhat lengthy one. Obscure hints of the phosphorescent power of gems are contained in some of the works of the ancients, but nothing definite was discovered until about the year 1602, when a shoemaker of Bologna, named Vincenzo Casciorolo, picked up a heavy stone, and being an enthusiastic alchemist, took it home and treated it in his furnace, in the hope of obtaining gold from it. Instead of getting gold he obtained a mass which shone in the dark, and which became celebrated as the Bologna stone, or Bologna phosphorus. The stone was the now well-known heavy spar, and acted on by carbon it yielded barium sulphide, a compound of considerable phosphorescent power. In 1663 Boyle published some observations on the phosphorescence of the diamond, and in 1675 Baudoin obtained another phosphorus by the action of heat on calcium nitrate. Some important additions to our knowledge were made by Beccaria in 1744, and then came the discovery by Canton in 1761, of the phosphorus or pyrophosphorus which bears his name. It is made by calcining oyster shells with sulphur, and consists, of course, essentially of calcium sulphide, which is the most remarkable of phosphorescent substances. Thanks to the kindness of my friend, Professor Tuson, I am able to show you a sealed tube containing a specimen of this substance prepared by Canton himself, with the date, 1764, engraved on the glass. It still retains its power, a remarkable proof that the luminosity is not due to any chemical action.

In 1775 Wilson published some valuable discoveries. He extended the list of phosphori, showed that light of various colors could be obtained from them, and made some interesting observations on the effects of heat and cold, to which I shall refer again. I have here a sheet of cardboard painted with various phosphorescent compounds, and a butterfly painted on glass in the same manner. On exposing them to light you will observe the different shades of color, varying from red to blue, which are developed.

Passing by, in this imperfect sketch, several important names, we come to the greatest name of all, Edmond Becquerel, who for more than thirty years has enriched science by his discoveries. It is impossible for me to give even an abstract of these discoveries. He invented an instrument called the phosphoroscope, by which he was able to detect the phosphorescent power in bodies which remain luminous for very short periods of time. He showed that the power was a very common one in natural as well as artificially prepared substances, and that it was possessed by organic as well as inorganic compounds, and particularly by all fluorescent substances. He analyzed the light emitted in each case by the spectrum, and determined its duration within certain limits of accuracy. These limits are singularly wide, extending from less than the five thousandth part of a second to hours or even days. Of all phosphorescent bodies, the sulphides of calcium, barium, and strontium are the most remarkable in regard to the duration of their light; and Becquerel has studied the modes of preparing these compounds with the greatest care, and has revealed many strange and even startling facts in regard to them. They can be prepared by the action of carbon on the sulphates, by the action of sulphur on the oxides and carbonates, and by the action of alkaline sulphides, and even of antimony sulphide, on the last-named compounds. The phosphori prepared by these various processes differ widely in regard to the color and duration of the light which they emit, and it is even possible to obtain shades varying from orange red and indigo blue from calcium only. But this is not all. The calcium sulphide obtained from calcite is different from that from arragonite, though these minerals have the same chemical composition; and the differences remain even after each mineral has been dissolved in acid, re-precipitated by sodium carbonate, and then ignited with sulphur. This affords a strange and, for the present, inexplicable example of molecular persistency. Becquerel holds that fluorescence and phosphorescence are one and the same phenomenon, the apparent differences being due solely to the different periods during which the absorbed light is emitted. The point is one which merits attentive study.

We now come to the immediate subject of my lecture. The late Mr. Balmain, formerly of University College, and an excellent chemist, had for many years made a special study of phosphorescent substances. He enjoyed the friendship of the Becquerels, father and son, and, aided possibly by them, he succeeded in producing a constant and very powerful phosphorescent substance. Here is some of the substance. You see how strong a light it emits after exposure to the magnesium light. It occurred to him to patent the use of this and other phosphorescent materials, mixed with water or oil, as paints capable of being applied in the ordinary way to any surface. This patent for luminous paint is now in the hands of Messrs. Ihlee and Horne, of Aldermanbury, and, thanks to those gentlemen, I am able to show you a great many specimens of articles thus painted, and to enable you to judge for yourselves of its proposed applications. I have, in the first place, a number of sheets of cardboard so painted, some of them framed and glazed, which you see emit, after insolation, an amount of light which is remarkable. With these sheets we can try a few preliminary experiments, which will assist in illustrating the nature of the phenomena with which we are dealing. Let us, in the first place, test the sensitiveness of the paint. Exposing a sheet of painted card, previously kept in darkness, to Leyden jar sparks from an induction coil, you see that each spark impresses its image on the card and makes it luminous. It is easy in this way to write luminous words on an otherwise dark card. You know how very short a time each spark lasts, and can therefore judge of the short time required for the illumination. The same fact is more roughly shown by striking a lucifer match in front of a dark pane. The momentary flash of the tip is, you see, enough to produce a very visible effect on the paint.

We may now try the very obvious experiment of applying light of various colors to the painted surface. Here is a card partially covered with sheets of blue, green, yellow, and red glass. Burning a piece of magnesium in front of it, you see that no effect at all is produced by the red and yellow light, a considerable effect by the green, and most of all by the violet light. The same effect may be produced in another and less ambiguous manner. We will throw the spectrum on a white screen, which consists of five horizontal layers. The upper one is white paper, the next, sensitive photographic paper;* the next, paper saturated with quinine; the next, luminous paint, which at present is dark, and the lowest luminous paint previously insolated. The spectrum covers all these layers. A long exposure is required to give a very satisfactory result, but we are then able to make out that there is great general similarity between the rays which affect the silver, the quinine, and the luminous paint. The affected portions are nearly, but not quite, coincident. If the experiment is carried on for a long time with a very intense spectrum, another effect which we could not have anticipated is observed in the lowest layer, which has previously been made luminous. The violet and ultra violet rays increase the luminosity, as we might have expected, but the yellow and red rays not only do not add to the luminosity, but actually take away the light previously present. Another experiment will show this effect more quickly. Here is a sheet, at present luminous; I cover half of it with opaque cardboard, and the other half with yellow glass, and then burn a piece of magnesium in front of it. See the result. The rays which passed through the yellow glass have taken nearly all the light out of that half of the card, while the light on the other remains unimpaired.

For an explanation of this curious phenomenon, we must go back one hundred and five years, to Wilson, who first observed it, though in a different manner. We must remember that red and yellow rays are also heat rays; and Wilson showed that heat would stimulate the light for a time only to cause it more rapidly to disappear. On a faintly luminous pane I place a can of hot water. Removing it after a minute, we find that the light in that place is much brighter than before. Cold diminishes the light, which, however, returns when the original temperature is restored. This I can easily show by applying a block of ice for a minute to the luminous surface. Thus we see the importance, in all experiments on the duration of phosphorescent light, of paying close attention to temperature.

We may now inquire how far this luminous paint is suited for actual use, and what kind of applications can be found for it. We have seen that it is very sensitive to artificial light. To ordinary daylight it is at least equally sensitive, and I have seen it tried, with a success which seemed to me wonderful, in a thick yellow London fog. A very short exposure produces the maximum of illumination, though, of course, the amount of this illumination depends on the quantity and quality of the light. The duration of the light is likewise dependent, to some extent, on conditions. When the paint has been exposed to the intense light of the sun, or of burning magnesium, a good deal of the brilliancy disappears quickly, but after that the fading is very slow; and it may be said that a more or less useful light will remain through the length of an ordinary winter's night. In an extreme case, I was just able to see the dial of a watch by the light emitted from a card which had been in total darkness for twenty-six hours. In this case the card had been exposed to daylight of moderate intensity for two hours.

The next point to be considered is the durability of the paint. The oil seems to protect it wonderfully, even from the acid air and rain of London. I have seen a wooden bowl, which was painted by Mr. Balmain more than a year ago, and has for several months been exposed to the open air in London, in very bad weather. It still preserves its power. Equally effectual is the oil as a protection from water. Here you see the painted model of a life buoy immersed in water. Its luminosity is very evident. In several respects, therefore, namely as regards intensity of light, lasting power, and durability under fair condition, these painted surfaces seem likely to be useful as carriers of daylight into dark places and through dark hours.

Let us now turn to the suggested applications of the paint. They may be divided roughly into the ornamental and the useful, and I need only mention a few out of the many that occur to the mind. In the former class, we may include these painted India-rubber balls, which are very pretty, and suggest nocturnal lawn tennis. Statuary, grotto work, and ornamental tiles, also give striking and beautiful effects. Here is a large bust of the Prince Consort which has been painted and illuminated. You see how fine an effect it produces. Clock faces, so prepared, show the time all night, and watch boxes enable us to do as much with our watches. The ends of lucifer-match boxes have been painted with the same material. Here are a number of them. There would obviously be no difficulty in finding one of these boxes in the dark.

To pass to more important applications, the roofs of railway carriages have already been treated experimentally with the paint, with results that appear satisfactory. The light would, of course, only be employed for daylight trains which run through tunnels. Then, again, it is proposed to paint the names of streets, the directions at post-offices, sign posts, and advertisements in the same way. Here are some framed notices, "Lodgings," "To Let," and such like, which would easily be seen through, at any rate, a great portion of the night. Still more important is the use of this luminous power in gunpowder magazines, spirit stores, and for purposes of exploration in coal mines during seasons of danger, and many such uses may be thought of.

But of all the proposed uses of the luminous paint, none seem to me so important, or so certain of practical success, as the marine applications. Several of these have already been realized in a satisfactory manner. For signal and mooring buoys, for example, its utility is obvious. It is of the utmost importance that the buoys employed for marking channels should be seen easily, the safe entrance to a harbor or river frequently depending upon the successful passage through a line of buoys. The entrances to Poole Harbor and to the mouths of the Thames and Medway are marked in this way, and great difficulty and danger are often experienced on dark nights in making out the buoys. Now, there can be no doubt that a buoy thickly painted with luminous paint would remain visible through the whole, or nearly the whole, of a night. A few evenings ago, I assisted at the trial of a small mooring buoy at Erith. It was not placed in the water till nine at night, having, of course, been for some hours before in darkness. We found that it was easily visible at distances of over a hundred yards, although the night was not a clear one, and the light to which the buoy had been exposed had not been very good. Yachtsmen, returning to moorings late at night, would find such buoys a great advantage, and many collisions might in this way be avoided. Equally important is the application of the paint to life buoys. Life buoys are, or should always be, kept on deck in convenient situations. A life buoy thrown to a man overboard will often save his life, particularly if the man can swim. But what is the use of throwing out a common life buoy on a dark night? It is impossible for the man to see it, and equally impossible for those on board. Here is a life buoy painted with the luminous paint. It has been on the roof of this house all day, and has, consequently, been now for several hours in darkness. Yet you see it emits a light that could easily be seen at a very considerable distance. Any decently good swimmer could easily reach it, while the ship's boats would know at once the point to which they must row.

Finally, there seems no doubt of the usefulness of the paint in diving and other submarine operations. We have ready a diver in full dress, painted all over with the luminous paint. He is being illuminated in the next room. Now he enters, and you see what a brilliant and ghost-like appearance he presents. At present one of the greatest difficulties in submarine operations arises from the intense darkness. With this new arrangement every diver will be his own lantern, and will carry down with him a stock of daylight that will assist his labors materially. This dress was actually so used at Southampton a day or two ago. Mr. Phillip Hedger, the superintendent of the Southampton Dock Company, has sent this letter to Messrs. Ihlee and Horne, in which he says that the diver descended on a somewhat murky day into twenty-seven feet of not very clear water, and found that he was able to distinguish the boltheads and mussels on a ship's bottom with ease. Mr. Hedger seems to entertain no doubt of the success of the new application.

Let me, in conclusion, draw your attention to the splendid inscription, "Balmain's Luminous Paint," which stretches in letters of fire the whole length of the hall. It has been in darkness for two hours, and yet illustrates very simply the way in which the paint may be made useful for advertising purposes.

I may now conclude this brief and very imperfect sketch. I heartily wish the exposition had fallen into better hands, and particularly that our chairman, whose well-known researches on actinic light have added so much to our knowledge, would have taken the matter in hand himself. However, I have done my best, and can only hope that you have acquired some new ideas on the subject, and will in future watch with interest for further useful application of the luminous paint.

I must here express my sincere thanks to my friend, Mr. Bolas, himself so excellent a lecturer, for his invaluable help in the experimental portion of my lecture.

* Kindly prepared for me by Mr. J. M. Thomson, of King's College.

NOTES ON SOLUBILITY.*

By D. B. DOTT.

BEFORE proceeding to the matters more particularly pertaining to this paper, it seems desirable to say a few words on the general subject of solution.

Dr. Watts, in his "Dictionary of Chemistry," defines solution as "the liquefaction of a solid or gaseous body by contact with a liquid, the solid or gas being diffused uniformly through the liquid and not separating when left at rest." In the same article we read: "The product formed by the union of liquids one with the other is usually called a *mixture* if the two liquids are capable of uniting in any proportions whatever, and a solution when each of the liquids is capable of taking up only a limited quantity of the other." The definition is certainly incomplete without taking the last quotation as a qualification, for a liquid manifestly dissolves in another liquid in the same manner as does a solid or a gas, showing that there is no preliminary or accompanying liquefaction. I cannot leave these quotations without condemning what has always appeared to me a somewhat meaningless distinction between *solubility* and *miscibility*. It is customary to say, for instance, that ether dissolves a small proportion of water, but that ether and alcohol are miscible in all proportions. Is the difference here anything more than one of degree? When it is said that two liquids are perfectly miscible, is it not just another way of saying that each is capable of dissolving its own volume of the other? Moreover, the term *miscibility* is occasionally applied to that intimate mixture of liquids which is sometimes observed—as, for example, chloroform with glycerin, where the two liquids mix thoroughly so as to simulate solution, but after some time slowly separate. Indeed, this appears the more appropriate use of the expression.

I have read with interest in the *Chemical News* (vol. xxxvii., p. 47) a paper by William Durham "On Suspension and Solution." After describing a number of experiments founded on such facts as the precipitation by sulphuric acid of clay suspended in water, which phenomenon is explained by the greater attraction of water for sulphuric acid than for clay, he concludes as follows:—"There seems to be a regular gradation of chemical attraction from that exhibited by the suspension of clay in water up to that exhibited in the attraction of sulphuric acid for water, which we call chemical affinity. Chemical combination, solution, and suspension differ only in degree, and are manifestations of the same force." Although, doubtless, these conclusions would not generally be admitted, I believe they are fundamentally true. Just as we have a gradation from a perfect gas through intermediate stages to a liquid, and from a liquid through various degrees

* A condensed report of a paper read before the Edinburgh University Chemical Society, February 11, 1880.

of viscosity to a solid, so we may say that there is a gradual increase of force from mere adhesion up to the most unmistakable instance of chemical affinity. For the sake of convenience, however, there is no harm in distinguishing two classes of material phenomena, the physical and the chemical, and there should be no hesitation in referring solution to the former. It is true there are one or two facts which give some support to the chemical view of solution; such as the precipitation by water of a resin dissolved in alcohol, as likewise the instance already referred to in Mr. Durham's experiments. From the same point of view the solution of a salt in water may be regarded as a combination of the salt with water to form a fluid hydrate, which then diffuses through the liquid. On the other hand, combination in definite and multiple proportion, and other characteristics of chemical action which it would be superfluous to recite, have no place in solution, so that we are compelled to place solution among the purely physical phenomena.

Perhaps the best definition of solution I have seen given is that by Dr. Isidor Walz (*Pharm. Journ.*, [3], vi, p. 8), who gives the following expression:—"Solution is the penetration of the molecules of one or more substances into the inter-molecular spaces of another substance, and the consequent formation of a homogeneous resultant." My only objection to this definition is that it includes among solutions, alloys and hydrates, as well as mixtures of gases, while it is unusual and confusing to speak of solution except in reference to liquids. The definition I have devised, although no doubt open to objection, better expresses, I think, the nature of the process than the definitions sometimes given:

Solution consists in the Molecular Mixing of Distinct Liquids.

1. The degree of solubility extends from zero to infinity, and depends upon the nature of the liquids and upon the temperature and pressure.
2. When a solution under given conditions is incapable of dissolving more of one of its constituents it is said to be saturated as regards that constituent.
3. In the case of solids and gases solution is preceded or accompanied by liquefaction, which is brought about by contact of the liquid with the solid or gas, the resulting solution not being capable of liquefying a substance after it has attained its point of saturation for the same.

We come now to those instances of solubility which suggested to me the writing of this paper. So far as I am aware it is not generally known that many alkaloidal salts are much more soluble when in the amorphous anhydrous state than when in the crystalline hydrated form. The salts to which my attention has been more particularly directed are the meconate of morphia and the hydrochloride of beberia. The neutral meconate of morphia crystallizes from water in prismatic needles, having, when air-dry, the composition represented by the formula—

$$(C_{17}H_{19}NO_3)_2{\cdot}C_7H_4O_7{\cdot}5H_2O,$$

and when dried in the water-bath the five molecules of water are eliminated. Beberia hydrochloride has the composition when crystallized indicated by—

$$C_{18}H_{21}NO_3{\cdot}HCl{\cdot}4H_2O.$$

In dry air three of these molecules are given off, but the last is not lost under a temperature of about 120° C. As regards the solubility of these salts I have had some difficulty in coming to an exact conclusion. Storer distinguishes the two recognized methods of determining solubilities as the "method by digestion" and the "method of cooling." In the former of these the solvent has added to it an excess of the substance whose solubility is to be determined, the temperature being kept as nearly constant as possible, and the solution is agitated from time to time. If at two of these intervals the proportion of dissolved substance is found to be the same the solution may be considered saturated, and the results taken as correct. In the "method of cooling" a saturated solution is prepared at a certain temperature, and the solution is then allowed to cool to the temperature at which it is desired to determine the solubility. After remaining a sufficient time at that temperature, the amount of dissolved substance is estimated in the usual way. The question arises, What is a sufficient time to allow the solution to stand at the temperature finally attained before making the determination? Gay-Lussac in his experiments found that two hours were enough, and I observe that more recently (*Chem. Soc. Journ.*, 1876) Victor Meyer recommends the same time. Storer is of opinion that wherever practicable the "method by digestion" ought to be followed, and that the employment of the "method of cooling" is principally responsible for the striking discrepancies in nearly all accounts of this class of constants, the source of error being the tendency of many substances to an indeterminate supersaturation when cooled from a higher to a lower temperature. If a sufficient length of time were allowed the results obtained by both methods would probably ultimately agree, but no adequate allowance has been made for this tendency to "supersaturation." *Two hours* may be a sufficient interval for some solutions, but *three days* are not sufficient for others, as the following figures will show: A saturated solution of morphia meconate, was prepared by "method of cooling." After remaining for two or three hours at 10° 278·96 grs. H_2O contained 28·95 grs. of the crystallized salt, or 1 part is soluble in 3·6 parts H_2O. After three days, 178·63 grs. H_2O contained 5·94 grs. salt, or 1 part is soluble in 30·6 parts H_2O at 10°. Of the same solution after ten days (t=11°) 108·57 grs. H_2O contained 3·13 grs. of the salt, or one part is soluble in 34·6 parts H_2O. Similarly with a solution of morphia neutral tartrate. On the first day the proportion dissolved was 1 in 5·0; on the second day, 1 in 6·2; on the fourth day, 1 in 11·0; the temperature varying slightly on these occasions, but not in such a way as to account for the divergence in the results. What I wish particularly to call attention to, however, is the great difference in the solubility of these salts when crystalline and hydrated and when amorphous and anhydrous, as I have no doubt the tendency to "supersaturation" depends on the same cause. The solubility of morphia meconate (5-hydrate) was determined by "method by digestion" (t=12°). 54·93 grs. H_2O dissolved 2·098 grs. of the crystallized salt, or 1 part is soluble in 26·1 parts H_2O. 94·45 grs. H_2O dissolved 3·592 grs. of the salt, or 1 part is soluble in 26·2 parts H_2O. We may therefore take the solubility of di-morphia meconate penta-hydrate as 1 in 26 of water at 12°. Of the anhydrous salt, 100 grs. of H_2O dissolved 45 grs. at 11°, or 1 part is soluble in 2·2 parts of water. This result must only be taken as giving the minimum solubility, as it is impossible to digest a solution with excess of the hydrate for any length of time without crystals of the 5-hydrate rapidly forming. I have not so carefully ascertained the solubility of beberia hydrochloride, but 1 part of the crystallized salt is soluble in about 30 parts of H_2O at 18°.

On the other hand, the amorphous salt, whether dried in the water-bath or by exposure to the air (in which latter case it contains very nearly the proportion of water for the 4-hydrate), is soluble in water to almost any extent.

The question I have put to myself is this: What is the explanation of these salts being so much more soluble in the anhydrous amorphous state than when in the hydrated crystalline state, and what is the cause of their tendency to form "supersaturated" solutions? Perhaps the explanation which most readily suggests itself is that the anhydrate and hydrate being distinct compounds, the former is more soluble than the latter, and that when a hot solution of the hydrate is prepared the hydrate decomposes into the anhydrous salt and water, while again, on the solution cooling, the anhydrate slowly re-combines with water to form the less soluble hydrate. This theory, if it agreed with all the facts, would be quite satisfactory; but there is at least one phenomenon which tends to disprove it. I refer to the avidity with which moisture is absorbed by some of these amorphous salts, notably by morphia meconate. Portions of this salt, prepared by evaporating a solution to dryness on the water-bath, were placed under bell-glass with a beaker of water. Moisture was rapidly absorbed, the substance becoming sensibly wet to appearance and to the touch. On weighing these portions at intervals of twelve hours the maximum gain observed was 29·6 per cent. The weight then decreases pretty rapidly until the absorbed water is —13·6, and then the salt gradually dries up to the 5-hydrate. The percentage 13·6 agrees pretty well with that required for a 6-hydrate, 14·02, 11·68 being the increase required for the known 5-hydrate. These results rather militate against the theory of such salts dissolving as anhydrates. One would naturally expect that when a salt has a great affinity for water it would combine with the water when thrown into it previous to dissolving. Another view which may be taken of the phenomena under discussion is the assumed existence in solution of different hydrates of varying degrees of solubility. As is well known, this is the explanation usually given of the formation of supersaturated solutions of sodic sulphate, etc. We can imagine that when the anhydrous salt is added to water it immediately combines to form its highest hydrate, but that the least soluble hydrate gradually separates according to the same law by which the least soluble salt separates in a case of double decomposition. This explanation is still open to objection. If the least soluble hydrate has a strong tendency to form out, why does it not do so at once? Now, it is evident that the conclusive point to determine is whether the high degree of solubility adverted to is a function of the anhydrous state or of the amorphous state. It has often been noticed that alkaloids when recently precipitated and in the amorphous condition are more soluble than when after standing some time they have become crystalline. It is easy to prepare amorphous hydrates of morphia meconate and beberia hydrochloride, having apparently the same composition as the described crystalline hydrates, and their noncrystalline salts are extremely soluble. More decisive than any of these is the experiment next described. If morphia meconate 5-hydrate be dried in the water-bath it still retains its crystalline appearance, unlike the anhydrate prepared as formerly described. Let it now be digested with water, and it is found to be no more soluble than the ordinary crystallized salt.

It must often have been observed that the presence of small quantities of coloring matters and the like greatly interferes with the separation of organic salts and crystalline principles from their solutions. That is to say, that a hot solution of such a strength that, on cooling, it becomes filled with crystals, will cool down to the same temperature without yielding any crystals, if only certain impurities are present, the substance slowly crystallizing out after some time, and this with compounds which are not known to form hydrates. It is sometimes remarked of such instances that the substance is more soluble in a solvent containing coloring matters than in the pure menstruum; but this is misleading if not quite incorrect, seeing that the coloring matters are present after the crystals have appeared, just as they were at first. In some cases mere traces of such coloring matters almost prevent a salt crystallizing.

Having given a considerable amount of attention to this class of phenomena, I have come to the conclusion that these are genuine instances of "supersaturation;" that is to say, that these compounds are not rendered more soluble by the presence of coloring matters, in the same way as calcic sulphate is rendered more soluble in water by the addition of hydrochloric acid; but that the coloring matters in some manner interfere with the formation of crystals, and favor the condition of "supersaturation." This depends, I believe, on the capacity of dissolved substances for existing in two distinct states, what we might perhaps call the *potentially amorphous* and the *potentially crystalline*, corresponding to the amorphous and crystalline conditions of solid matter. Assuming the possibility of this, we can then readily believe that colloidal coloring matters, being themselves incapable of crystallizing, will tend to retain other dissolved substances in the same state as themselves, and thus retard the formation of crystals.

This theory of a twofold liquid state may seem a very large conclusion from meager premises, but I feel convinced that some such theory is requisite, and that other phenomena besides those referred to will be found to favor this view of the matter. If it be true, for instance, as has been stated, that if the same salt solutions prepared in different ways will dialyze with very varying degrees of rapidity, it would seem that the same salt can exist in two liquid states.

RECENT CHEMICAL PROGRESS.

MR. WARREN DE LA RUE, President of the London Chemical Society, speaks of recent chemical progress as follows:

"The elements once looked upon as most stable are now considered to be at any moment liable to be dissociated. Some months back spectroscopic evidence was brought forward which tended to show that the so-called elements were in reality compound bodies; and now V. Meyer has succeeded in dissociating chlorine, bromine, and iodine. As regards the spectrum itself, specific functions and properties can no longer be attributed to various parts of it; for Captain Abney has shown that every part acts actinically, and holds out a prospect of producing permanent photographs of the spectrum in its natural colors. The artificial production of the diamond is also said to have been effected, but Mr. Hannay's communication on this subject is so vague that it is impossible to pronounce any opinion upon it. The joint observations of Hannay and Hogarth on the solubility of solids in gases promise results of great interest. Remarkable observations have been made by Cailletet, Anedell, etc., on the behavior of various substances, mixtures, etc., under great pressure. The researches of Gladstone, Landolt, and others, on the refractive indices of carbon compounds, have been greatly extended by Bruhl."

The President then alluded briefly to the great diligence of organic chemists in the investigation of carbon compounds, and especially to the elucidation of the constitution of alkaloids and the carbohydrates. The synthesis of isatin and Baeyer's researches in the indigo group must, it would seem, result ere long in the discovery of a method for the artificial manufacture of indigo. Ladenburg has prepared atropine from tropine and tropic acid, and thus probably the first steps have been taken toward the synthesis of an alkaloid. Much light has been thrown on the constitution of the bases of the pyridin and picolin series, of the nicotin and cinchona alkaloids, and of starch. Recent facts seem to show that our present symbolic system is inadequate to represent the constitution of carbon compounds. A new element, scandium, has been separated, corresponding to Mendelejeff's ekaboron, thus verifying his sagacity and the importance of the "Periodic Law."

HOW SALICYLIC ACID IS MADE.

THE following report of an English patent suit is full of interest:

COURT OF APPEAL.—(Before Lords Justices JAMES, BRETT, and COTTON.)—*Von Heyden v. Neustadt.*—The plaintiff in this action, M. Friedrich von Hayden, brought the action against the defendants, Messrs. M. Neustadt & Co., of Mincing lane, to restrain an alleged infringement by them of the plaintiff's patent for the manufacture of salicylic acid. The patent was granted on the 17th of February, 1874, to Mr. J. H. Johnson, for an invention communicated to him by Professor Hermann Kolbe, of Leipsic. Johnson was a trustee for Kolbe. The patent was afterward assigned by Johnson and Kolbe to the plaintiff. The defendants have been selling in this country salicylic acid, imported by them from the firm of Emanuel Merck, of Darmstadt, manufacturing chemists, which had been made by that firm according to the method described in a patent granted on the 3d November, 1877, to Max Neustadt, one of the defendants, as a trustee for the firm of Merck, and afterward assigned to that firm. Vice-Chancellor Bacon granted the injunction claimed by the plaintiff. The defendants appealed.

The *Attorney-General* and *Mr. Everitt* were for the appellants; *Mr. T. Aston, Q.C.*, and *Mr. Macrory*, were for the plaintiff.

Lord Justice James now gave an elaborate judgment in favor of the plaintiff, from which we extract the following:

In this appeal the defendants, the appellants, disputed the validity of the plaintiff's patent on the ground of want of novelty, and also contended that there was no sufficent evidence of infringement. Assuming the novelty to be established, it was contended that the invention was not a useful one, nor that the specification was insufficient.

The specification begins with a statement, the accuracy of which is admitted by the scientific witnesses of the defendant, that when the patent was taken out salicylic acid was produced in two ways—either by introducing carbonic acid into boiling carbolic acid, sodium being simultaneously dissolved in the latter, or by the employment of the expensive and not easily procurable oil of wintergreen, *Gualteria procumbens*. The specification then states in substance, reducing the language to its briefest terms, that the invention consists in effecting the production of salicylic acid by the action of carbonic acid gas on carbolic acid in the presence of an alkali or alkaline earths, and doing this in large quantities and at a great reduction in price. The words, "in presence of an alkali," etc., refer to one of the most strange things in the chemical action of bodies on one another. It has been found that sometimes two bodies, which have little or no action on each other, are made active by the introduction of a third body, which is itself apparently inert and passive, neither affecting nor undergoing any change. And the principle which underlies the process patented by the plaintiff is this: Carbonic acid has no effect on carbolic acid; but if a certain compound be made of carbolic acid and soda, and carbonic acid be introduced into this compound, heated, then the carbonic acid immediately attacks, not the soda, but the carbolic acid, the greater part of which it transmutes into salicylic acid, which remains in combination with soda, so much of the carbolic acid as is not transmuted being disengaged and driven off. The patentee, as to his *modus operandi*, says in substance: I take caustic soda, dissolve it in carbolic acid in a retort, heat it to the boiling point of carbolic acid (183 degrees Centigrade) until all the water and the greater part of the excess of carbolic acid is driven off (the same being preserved for future use); then I conduct a stream of dry carbonic acid gas into the retort, and raise the heat to somewhat above 200 degrees Centigrade. The entire mass will gradually become solid, and the operation is terminated when but little residual carbolic acid distills over. Or instead of taking an excessive quantity of carbolic acid and dissolving the caustic soda in it, I take the two in exact chemical equivalents and combine them, and by heating and agitation get rid of all the water, the substance, if dephlegmated as much as possible (by which, we understand, deprived of everything that can be called moisture—metaphorically, humor or phlegm), is to be transferred into a retort and treated with carbonic acid gas, as above. The result, which is a salicylate of soda, I wash with water, and from it I precipitate the salicylic acid by hydrochloric or other suitable acid.

This is the process, and there is no doubt that by means of it the carbolate of soda is converted into salicylate of soda, and that, practically, the whole of the salicylic acid is obtained from that compound.

It is not disputed that this actual process has never been used in works or laboratory for the production of salicylic acid, either for sale or for any other practical purpose or use whatsoever. Nor is it disputed that a product of great value and previously very dear is obtained by it most economically. By whomsoever the process was really discovered, it is one of singular beauty as a chemical operation, and of singular efficacy and utility as a manufacture. The article was quoted in 1868 at 13s. an ounce; it is now sold at 7s. 6d. a pound. And it has come into general use, not as a useful medicine, but as a powerful antiseptic.

But it is contended that it is not novel because it is anticipated by information given to the world in prior publications, being part of the common stock of knowledge possessed by the chemical portion of the public. The burden of proving this anticipation is on the defendants, and it must be made out very clearly in order to destroy the patent of a man, who, at all events, was the first person, who, *de facto*, produced this thing to the public practically in a working state. Now, on that subject Lord Westbury held in the Court of Chancery, and repeated and adhered to

it in the House of Lords, that the anticipation contained in a prior publication must give really the same full and sufficiently precise information which is required in a specification. If it were necessary in this case we should be prepared to adhere to and act upon that view of the law. But what we have got in this case is not one clear statement by one writer, but a mass of paragraphs exhumed by the industry of the defendants' advisers from a number of publications. We are of opinion that if it requires this mosaic of extracts from annals and treatises spread over a series of years to prove the defendants' contention, that contention stands thereby self-condemned As for annals, in particular the annual registers of science, one knows that in every country every year thousands of facts, or supposed facts, find their way into them, coming like shadows and so departing, without leaving any permanent track behind them. And if it could even be shown that a patentee had made his discovery of a consecutive process by studying, collating, and applying a number of facts, disseminated in the pages of his works, his diligent study of such works would as much entitle him to the character of an inventor as the diligent study of the works of nature would do.

We have, in addition, this broad fact, that with all the knowledge supposed to be communicated by chemical publications, no one did before the patent make an ounce of salicylic acid through the use of caustic soda, or by this or any other process make salicylic acid at any practical price for general or commercial use.

The whole may be summed up thus: No one before the patentee had ever practically or theoretically taught the world how to make out of such abundant and cheap materials as soda, carbolic acid, carbonic acid gas, and hydrochloric acid, the rare and expensive thing, salicycle acid; no one had ever before taught the world the simple and fruitful chemical truth that all that was required to effect this wonderful transmutation was to make the carbolate of soda perfectly anhydrous and perfectly desiccated.

We now come to the second part of the case. Is there evidence that the defendant has infringed the patent for the plaintiff's invention? The defendant admits that he has obtained the article which he sells by Neustadt's process as patented by him. Now, the only distinction between the one process, as patented, and the other, is, that Neustadt begins with anhydrous carbolate of soda. The witnesses for the plaintiff say that there is now no other practical mode of obtaining it than the plaintiff's, and that they have no doubt that it is so obtained. The defendant, who must know how he obtains the materials, has given no evidence to the contrary. We are, satisfied, therefore, that the evidence of the plaintiff's witnesses in this respect is accurate, and that the defendant has imitated, and in fact adopted, the plaintiff's invention.

But in the course of the argument a doubt was suggested from the Bench whether, if a process is patented in England, and the patent is for the process only, and that process is imitated abroad, the importation of the product from abroad and the sale of it here, is an infringement of the patent. But it appears that very point was raised and decided by me, as Vice-Chancellor, in the case of "Elmslie *v.* Bourchier," as far back as the year 1869, and that that case was approved of, adopted, and followed by the Court of Exchequer in the same year.

The question, therefore, is to be determined by the true construction of the letters patent themselves. It was on that construction of the letters patent that the case of "Elmslie *v.* Bourchier" was decided; and we see no reason to doubt the conclusion there arrived at, that the whole right granted by the Crown to make, use, exercise, and vend the invention within the United Kingdom, and the right to have and enjoy the whole profit, benefit, commodity, and advantage accruing and arising by reason of the said invention, includes a monopoly of the sale in this country of products made according to the patented process, whether made in the realm or elsewhere.

It may be added that the patent, in another part, expressly forbids any person, directly or indirectly, to make, use, or put in practice the invention. A person who makes or procures to be made abroad for sale in this country, and sells the product here, is surely indirectly making, using, and putting in practice the patented invention. Any other construction would, in fact, in the case of any really valuable invention of a process, render the whole privilege granted by the Crown futile. When the patent was an English patent only, an imitator would only have had to establish his factory on the other side of the border, and now such an imitator would only have to establish his factory, or use the chemical process at Boulogne or Ostend, and he would effectually deprive the inventor of the "whole profit, benefit, commodity, and advantage" of his invention. And the more valuable the invention, the more certain it would be that the prohibition in the letters patent would be so indirectly avoided, that is to say, evaded.

We are of opinion, therefore, and conclude that the plaintiff has established the validity of his patent, and the infringement of it, and that the appeal must be dismissed with costs.

A CONTRIBUTION TO THE KNOWLEDGE OF CHLORINE.

By V. MEYER and H. ZÜBLIN.

THE researches of C. Meyer and of one of the present writers on the behavior of chlorine and iodine at high temperature prove the occurrence of a decrease of density to the extent of one-third of the normal value as quite universal in the case of iodine, while as regards chlorine, the like phenomenon is demonstrated only in one special case, that is when the chlorine is applied in the nascent state. The experiments on chlorine were not, like those on iodine, performed with the free element, but with one of its compounds, platinous chloride, which evolves chlorine gas during the experiment, so that the latter is always in the nascent state. It appeared, therefore, important to examine how preformed free chlorine would behave at the same temperature; or, in other words, to determine the vapor density of free chlorine gas at a red heat.

A porcelain vessel, maintained at a yellow heat in a Perrot furnace, was completely filled with pure dry chlorine, which had been evolved from hydrochloric acid and manganese peroxide, and successively purified by water, sulphuric acid, and phosphoric anhydride. After the chlorine had remained for some time in the apparatus, and had assumed the temperature of the furnace, it was expelled by means of a current of carbonic acid, led into a solution of potassium iodide, and its quantity was determined by titrating the liberated iodine with a decinormal arsenite solution. The porcelain vessel, still at the same heat, was filled with dry air, and this, also, after having assumed the temperature of the furnace, was expelled from the apparatus by means of a stream of carbonic acid, collected in a graduated tube over potassa lye, and its volume was determined in the usual manner. Thus were ascertained, *a*, the quantity of chlorine, *b*, the quantity of dry air contained in one and the same porcelain vessel at the same temperature, forming the needful data for calculating the density of the chlorine. The relatively small quantities of air or of chlorine contained in the handle of the apparatus which projects out of the furnace and in the short and narrow entrance and exit tubes, were determined separately and deducted from the total quantities of air (respectively chlorine), so that only such portions of air or chlorine as were in the ignited parts of the apparatus were taken into account. The apparatus at a yellow heat contained:

Chlorine, 0·06529 grm., 0·06706 grm., 0·06670 grm.
Air, 0·02539 grm. (mean of three determinations).

Hence the density of chlorine was found as 2·57, 2·63, 2·64, or in the mean 2·61. This number agrees satisfactorily with the value calculated for $Cl_2 = 2·45$, while when operating with nascent chlorine from platinous chloride at low temperatures, a similar value (2·42 and 2·46) was obtained, but at a yellow heat the numbers 1·65, 1·66, 1·66, 1·67, 1·60, 1·62, corresponding to 1·63, the value calculated for $\frac{2}{3}Cl_2$.

From these experiments there follows the interesting result that the dissociation of chlorine to molecules of the magnitude $\frac{2}{3}Cl_2$, which takes place on the employment of nascent chlorine at a yellow heat, does not appear at the same temperature when ready formed free chlorine is used; while, on the other hand, iodine, even when applied as a free halogen, undergoes the conversion into $\frac{2}{3}I_2$, and at a decidedly lower temperature.

What may be the cause of the different behavior of nascent and of free chlorine cannot for the present be ascertained. It may perhaps be sought in the less stable state which bodies are apt to show during the nascent state. But it is also possible that other and more mechanical causes may occur, upon which the authors will enter in a future memoir.

They wish to point out for the present that the existence of chlorine Cl_3, and of chlorine $\frac{2}{3}Cl_2$, at one and the same temperature, as these experiments prove, is distinctly analogous to the fact that oxygen and ozone, which in their respective densities show the same relation as the two modifications of chlorine, can exist at the like temperature and even side by side.

The above-mentioned experiments were completed when the authors received information of the researches of M. Crafts (*Comptes Rendus*, xc., p. 183), on the density of the halogens at ignition temperatures. His results agree with theirs most perfectly. M. Crafts also found for iodine the density $\frac{2}{3}I_2$, but for chlorine, which he introduced into the apparatus in the free state, Cl_3.—*Berichte der Deutschen Chem. Gesellschaft.*

LONDON CHEMICAL SOCIETY PAPERS.

Combustion of Coal Gas, by L. T. WRIGHT. Some years ago the author was much struck by the powerful odor, suggestive of ozone, which he noticed when coal gas was consumed in a Bunsen burner in an atmosphere charged with the nitrogen oxides evolved from fuming nitric acid. During some experiments on the estimation of sulphur in gas the author passed the products of combustion of a Bunsen burner through solutions of iodine, and noticed that after the iodine solution had been bleached, and the current of gas stopped, free iodine appeared after some time in the solution. This reaction was attributed to nitrous acid, and was completely prevented by adding sodium bicarbonate to the iodine solution; the sulphur could then be determined by burning half a cubic foot of gas. In 1877 the author proved that nitrous acid was produced by the combustion of coal gas in ordinary air, but that if the gas and the air were both freed from ammonia no nitrous acid was formed (*Chem. Soc. Journ.*, 1879, *Trans.* 42); the futility of the ordinary methods of washing gases was also proved. The author has never had the least difficulty in obtaining a blue reaction with paper moistened with iodide of potassium and starch, when coal gas is burning in a Bunsen burner. Since reading Mr. Ridout's paper on the production of ozone, read before the society a few weeks back, further experiments have been made, and the author concludes that ozone is not formed by the combustion of coal gas, and that while ordinary gas burned in air usually gives the blue color with starch and iodide of potassium, no reaction is obtained when ammonia and its compounds have been completely removed previous to combustion.

Polysulphides of Sodium, by H. CHAPMAN JONES. These bodies were usually prepared by the direct union of sodium and sulphur. The author establishes the existence of Na_2S_5, which, on heating, gives off sulphur, and leaves Na_2S_4, it being extremely difficult to obtain the substances pure. The body Na_2S_4 seems to be the highest sulphide procurable; in a body containing more sulphur than the penta-sulphide the excess of sulphur seems to be merely dissolved. An aqueous solution of Na_2S_5, when gently warmed, evolves sulphureted hydrogen; the penta-sulphide cannot, therefore, be satisfactorily prepared by boiling a lower sulphide with excess of sulphur; on boiling the above solution no sulphur is precipitated, $Na_2S_2O_3$ and SH_2 being formed. The author has examined the action of cadmium carbonate and other cadmium salts on the penta-sulphide, and concludes that the precipitate consists of cadmium sulphide and sulphur, the latter being removable by carbon disulphide. The penta-sulphide is believed by the author to be a tetra-thio-sulphate; he hopes to be able to prepare the di and tri-thio-sulphates, and has obtained on several occasions a substance (giving a dark green solution having an absorption-band) which may be one of these bodies. In conclusion, the author gives some properties of a black residue which is uniformly left when sulphur is burned, but has not examined the substance, as Dr. T. Cross (*Berl. Ber.*, 1879, 788) is already investigating the subject.

Reflection from Copper, and on the Colorimetric Estimation of Copper by Means of the Reflection Cuprimeter, by T. BAYLEY. The author has shown that the light reflected from metallic copper contains all the elements of white light, but that the region of the spectrum to the red side of the D line is more intense than in the spectrum of the reflection from a white surface of equal illumination; the light transmitted by dilute solutions of cupric salts is deficient in those rays which the spectrum of reflection has in excess. It follows that if we look at a copper surface through a sufficient thickness of cupric sulphate solution, the metal appears silver-white, for the solution absorbs the excessive rays which make the copper red. Upon these facts the construction of the "reflection cuprimeter" is based. The direct light from the sky is reflected from a mirror of copper through two vertical tubes, closed at the bottom by plates of glass. The sheaves of light were concentrated by lenses on two layers of tissue-paper moistened with glycerine. The level of the liquid in the tubes can be adjusted by means of an aspirator. A standard solution of copper is made by dissolving one gramme of copper in nitric acid, adding excess of sulphurous acid, and diluting to a liter. It was found that a depth of 8·01 centimeters of this solution gave the silver-white tint to the copper reflector. Iron does not interfere if reduced to the ferrous state. The degree of accuracy is shown by analyses. The apparatus is made by Messrs. Jackson, 65, Barbican.

Pyrene, by WATSON SMITH and G. W. DAVIES. The crude material was obtained from Dr. Schuchardt, and consisted of a dark brown crystalline mass. This was purified by solution in petroleum spirit and crystallization. Crystals were light yellow; melted at 149°. A drawing of the crystals and a determination of the angles of the faces are given. The crystals are monoclinic. Analysis gave the formula $C_{16}H_{10}$. Vapor-density was found to be 6·912, calculated 6·999. The authors used Victor Meyer's method and a lead bath. They recommend smoking the glass, dipping into the melted lead in a luminous gas-flame; this prevents cracking and the adherence of the lead.

Ash of the Wood of Two Varieties of the Eucalyptus, by WATSON SMITH. The two varieties were the red and blue gum trees, *E. rostrata* and *E. globulus*. The wood is remarkably hard, and gives rise to a powerful aromatic odor when planed. Specific gravity of *E. rostrata* is 0·8112, of *E. globulus* 0·752. Ash, respectively, 2·25 and 2·01 per cent.; K_2O and Na_2O, 12·9 and 25 per cent.; CaO, 43·8 per cent.; 35·08 per cent., with small quantities of iron, alumina, etc. The author suggests the use of a decoction of the leaves of *E. globulus* as tea.

SEPARATION OF GOLD BY QUARTATION WITH ZINC.

By C. A. M. BALLING.

THE author criticises Jüptner's method (*Zeitschrift für Anal. Chemie*, 1879, p. 104), and points out certain defects. On melting the zinc with the alloy in an open porcelain crucible the former is partially oxidized, the film of oxide hindering the contact of the metals. If the fusion is performed under a layer of resin, the vapors become ignited and the resin is often burnt away before the fusion is effected. Even in a covered crucible the resin is also soon volatilized, whilst particles of carbon are deposited on the lid and the sides, and falling back into the crucible contaminate the alloy. The finer particles of carbon render the solution in nitric acid turbid, and cannot be entirely removed by washing. The author, therefore, modifies the process as follows: He used cadmium, which is more readily fusible for quartation, instead of zinc, and takes potassium cyanide as a cover. The metals unite readily under the melted cyanide at the heat of a Berzelius spirit lamp, and a homogeneous regulus is soon obtained. The crucible, when cold, is placed in a beaker, and the potassium cyanide is dissolved in water. The solution is poured away and the metal is washed with water. It is then introduced into a flask and boiled once with nitric acid of specific gravity 1·20, and then thrice with nitric acid of specific gravity 1·30. The cadmium is completely dissolved. Two and a half parts of this metal suffice for quartation. The granule of gold retains the form of the original metal and is transferred to a small crucible for ignition.—*Oest. Zeitschrift Berg. u. Hüttenw.*

SPECTROSCOPIC NOTES.

By HERMANN W. VOGEL.

THE author recommends chemists who have no Bunsen flame at command to use as a substitute the flame of hydrogen, with which he has succeeded in obtaining the spectra of the earths and alkalies. He also gives instructions for the detection of cobalt along with iron and nickel. Cobalt salts, dissolved in alcohol and mixed with potassic sulpho-cyanide, give a blue liquid with a most characteristic spectrum. This reaction became more important after Zimmermann had shown that the sulpho-cyanides of cobalt and nickel are precipitated by sodium carbonate, which the corresponding iron compound is not. Upon these facts the author founds the following method for detecting cobalt in presence of nickel and iron: The solution in which the iron must be present in the ferric state is mixed with an excess of ammonium sulpho-cyanide, and then with sodium carbonate, till the blood-red color has changed to a yellow. The whole is then filtered, and the filtrate shaken up in a test-tube with a mixture of equal volumes of amylic alcohol and ether. This mixture takes up the cobalt sulpho-cyanide from the aqueous liquid and floats on the top as a blue stratum, in which the absorption-band may be found between C and D.

DR. RICHARDSON, F.R.S., ON THRIFT IN RELATION TO FOOD.*

IF we take the twenty-five millions of people, who at this time form the population of England and Wales, and, dropping the millions, place them in our minds as a family of twenty-five persons, variously engaged, we arrive at a very comprehensible and important series of facts. The family easily divides itself into its component parts. We see six members of it —five out of six of whom are women—engaged in the domestic life. We see one—a man—actively engaged in commercial affairs, buying, selling, lending, and conducting transport service. We see two fully occupied in agricultural pursuits, cultivating land, growing food produce, and tending domestic animals. We see six—four of whom are men, two women—carrying out purely industrial pursuits, working at mechanical manufactures, weaving, preparing foods and drinks, or working on animal, vegetable, or mineral productions. We see eight, as scholars going to school, or as children at the nurse's breast, the futures of the great family. We see one, of indefinite life, doing no active work whatever, but tolerated by the community, or helped by it. These make up twenty-four of the family Lastly, we find one man, the twenty-fifth, standing at the head of the family, directing all its affairs. This man governs, defends, teaches. He is the legislator, the soldier and sailor, the policeman, the clergyman, the lawyer, the doctor, the artist, the journalist, the author, the professor, the schoolmaster. This man owns, practically, all the land, rules all the industry, and is, in fact, as much the head of the family, as the head itself is the chief of the body.

This is the family of the English people proper, living in England and Wales. The question is, how the one man

* Delivered at the Mansion House, London, March 12, 1880.

shall continue steadily to minister to the wants of the twenty-four persons under him. Those two men working on the farm, that one man trading, and those four men toiling in the shop, how shall he satisfy them so as to retain their continued support and loyal submission? Just at this moment that is rather a critical question.

The most critical question of all, relating to this family, is, that it shall be well and properly fed, or at all events, shall believe itself to be properly fed; for in truth, it might have all that is sufficient for its want, and a great deal more, and still consider itself over the brink of starvation.

My question is, what shall the twenty-fifth member of the English family teach and practice, in the way of feeding himself and the rest, so as to satisfy both the physical and the mental appetite? The difficulty he is under, in this dilemma, lies in the shortness of hands he has at his command for tilling the land and producing food, and the limitation of land to be tilled. The trader, it is true, comes to his assistance, and gives him a good proportion of food from abroad. If six hundred and fifty pounds in money's worth of food be requisite per annum to keep this family, the trader can insure one hundred and fifty pounds' worth, with promise of more; and so, with the trading supplement, matters go on without much pressure, friction, or disturbance. If the trader should fail in his task, if he should find outside supplies deficient, if he should find his home transformed into a citadel into which his supplies could not be imported without great cost and peril, then affairs would soon be bad indeed. The eight children would cry for bread; the eight women would second the children; the one trader, two agriculturists, and four artisans would be more than troublesome; and the one indefinite would not, I imagine, do anything reasonable to reduce the difficulty.

The facts I have here endeavored to simplify, so as to bring them home to the minds of all who are interested, are well known to those thoughtful statesmen who forecast the political meteorology with judgment and skill. They know truly that in the grand scheme of nature, carried out in her grandest manner, the principle of life is self-supporting. They know that nothing in nature, not a crumb that falls from the rich man's table, can ever be lost even as food.

While, however, they admit that nothing is lost in nature; that the amount of life on the earth is probably always the same; that death balances life, life death; that the animal life is always safe while the vegetable life is maintained; and that the vegetable life is always safe while the inorganic elements and the forces which move them are maintained; they never cease to detect the danger that exists in individual communities, while life itself is at war with itself, and while one sphere of life is dependent on the temper of another. To this little issue, resting on human passions, do the divine schemes of the universe itself, in their relation to men, come at last. Far-seeing statesmen, therefore, are not surprised at phenomena which, to common minds, come as surprises. They know that in vital human communities, the elements of which such communities are composed may, like saline matter in a saturated solution, remain disunited and mobile for unlimited time; but that the merest concussion, like the fall of a straw into the saline solution, may lead those elements, without loss of their structural essence to crystallize out in new forms, forms which remain permanent until some other new external and potent influence interferes to resolve and reconstruct once more.

On the food question, as a disturbing influence, different men take widely different views, even after they have appreciated its extraordinary importance. All in England have cause, I think, to admit that England cannot, under existing conditions, find sufficient food from her own soil for her own children. This is the darkest shadow of political calculation and thought that envelops the nation. It is only an eclipse, and that so partial as not yet to be visible at Greenwich; but it is present. Some of those who know of it believe that safety may always be insured by food supply from abroad, from our colonies, and from other nations, on comparatively easy terms; others think that by increased cultivation at home, by what is called model cultivation, we may so increase supply that we may be sure to meet whatever demands shall be made from increase of population and from increase even of luxury.

To my mind, these often expressed hopes are at best temporary and partial. When we come, for example, to deal with imported foods, putting aside all political embarrassments that may arise between food supplying and food receiving countries, and putting aside all natural failures at the sources of supply, there remain the two great obstacles —pressure of demand at the sources of supply themselves, incident to increase of population there; and cupidity in distribution of food that may be sent to us, after it has reached our shores.

Let me illustrate these points by what has recently occurred from the late importation of animal food from Australia by the Strathaven, refrigerating food vessel. I visited that vessel on its arrival in London, and inspected the preserved carcasses in their frozen chamber, and I have been able to follow up that great experiment in an instructive manner, as the facts I am about to state will show.

The cargo was purchased in the colonies at an average of 1¼d. per lb.; the cost of freight and expense of engineers is stated as 2d. per lb., making total cost, landed here, say 3¼d. per lb. The beef and mutton may be estimated as each costing exactly the same per lb. in the colony. A certain market, even at 1¼d. per lb., would satisfy the producers, but the effect of this new outlet would enhance the value of meat in the colony to 2d. per lb., to which add 2d. per lb. for expenses of freight, showing cost on landing here of 4d. per lb. Assuming the meat sold here wholesale at 5d. per lb., the shippers would realize a profit of 1d. per lb., equal 25 per cent., and this should be sufficient to satisfy persons embarking in the trade. The average price of the shipment per Strathaven, sold wholesale, was 5d. per lb. for the beef, and fully 5½d. per lb. for the mutton. The Smithfield retail price was 9d. for hind quarter, and 7d. for fore quarter, the average Smithfield retail price being 8d. The butcher's retail price was much higher than the Smithfield retail. "I heard," says the informant who furnishes me with these details, "of an honest butcher, who retailed the meat at 7d., stating openly that it was Australian meat; and another West-end butcher sold it to his particular customers at 10d. per lb., also stating it to be Australian." But no doubt many joints were bought and eaten as English.

In this short narrative, we see facts which, however slight they may appear, indicate direction of movement. They show how increase of price within a colony follows naturally on exportation of its produce, and they indicate how quickly, in a consuming community, trade influences modify and increase the cost price and the legitimate profits that should be based upon it.

When we come to deal with the question of model cultivation by the utilization of all so-called waste products, we find another source of doubt as to permanent results.

It is all right enough to say that we should utilize what belongs to the soil, and that would be a perfect step on the model of nature, if we were at the same time to derive the wasted product originally from the soil to which it is to be returned. This is not the case, however, when we depart, as we now do, from the soil for the original supply. Let me illustrate this by a calculation, which was once made in my *Social Science Review*, on a controversy relating to the subject of laborers' plots of produce. These plots were called model cases of produce in the midst of starved acres. The laborer, it was stated, knows that, if on his eighth of an acre of ground, he cannot keep a pig to make manure, he cannot expect a crop. He fattens, consequently, in order to get the manure, one pig. The pig consumes twelve bushels of barley meal, which at seven pounds of meal to one pound of meat would be eighty-four pounds of meat, or four score, on the one-eighth of an acre, or over thirty-two score per acre. At the same time the garden of this laborer is like an oasis in a desert. It receives in manure thirty-two times the farmer's quantity, and, as the man who makes the largest quantity of meat obtains a proportionate amount, both of manure and produce, the laborer is a model producer.

The reply to this argument was well handled, and was set forth as an argument altogether irrelevant to the solution of the question between food supply and population. The laborer truly, so ran the answer, fattens one pig, which consumes twelve bushels of barley meal, and makes the one-eighth of an acre an oasis. But thirty-six bushels of barley per acre is above an average crop, so that the laborer actually buys the produce of a quarter of an acre to manure his one-eighth. A very easy way indeed of making an oasis in a desert.

I adduce this illustration because I want it to illustrate a first principle as between food and population, namely, that while we must learn to turn wasted lands into fruitful, by cultivating on them varieties of food, by pushing discovery into new classes of foods, and by ascertaining what will yield different products, and by change of product yield still new products, we are not at model work when we go abroad for the foundation of our produce. To-day our foreign food yields a large part of the manure on which our own lands are directly fed, and from which we derive, through the land on which it is laid, the food it supplies. Thus, as it were, we temporarily import land from abroad, a process which, like the laborers' gardening, may go on very well so long as those abroad will send us what we want, but which would be a pitiful resource if, at any time, those abroad either want all for themselves, or in anger refuse us our requirements.

Whatever view, then, may be taken in respect to foreign supply of food and of model cultivation, we cannot depend in the future upon them. We may and ought to cultivate both; we must do so. We must cultivate, and not only cultivate, but establish a *third factor*, which, on the principle of a penny saved is a penny earned, must be second to none other. That factor is *thrift*. Our family of twenty-five must become a thrifty family through every member of it. From the all potent twenty-fifth man down to the indefinite helpless man through all the ranks, thrift must be the order of the day. The six hundred and fifty pounds' worth of food should be brought down to five hundred. How that is to be done is the question. The accomplishment of this object will be best secured in the following ways:

1 By giving up the use of substances used as foods which are not foods, but are inimical both to health and life.

2. By learning to use foods as near as possible to their first and cheapest growth.

3. By reducing the quantity of food used to the lowest practical working quantity.

1. Of supposed foods to be given up, one article stands out so prominently, that the removal of it alone would almost outweigh the value of all foreign food supplies at present imported. That article is alcohol. Our family of twenty-five spends a good hundred of its income on this article alone, or, turning it into millions, one hundred millions. Lord Derby is reported to have said a short time ago, that of sixpence spent in this way, fivepence is lost. Even that is an extreme view. The little residue, the fraction of food that is present in alcoholic drinks, really does not approach that calculation, while the injury that is inflicted on the family, the cost that is inflicted by the utterly useless and fearfully injurious action of that which inebriates, and does not feed either muscle, bone, nerve, or sense, but degrades them all, is an interest cent. per cent. on the fraction of food, levied with the most rigid and torturing exactitude.

2. In the way of learning to live on foods nearest to the first and cheapest growth, we must bring ourselves to use more freely vegetable foods and the fruits of the earth. The accomplishment of thrift through the use of vegetable substances and fruits is common sense itself, for when we use animal food, we, as a general rule, first use the animal that supplied the food to transmute the vegetable food into animal. It is true one flesh-eating animal may live on the flesh of another flesh-eater; the process is limited in range, and at the bottom of it there must be a first supplying animal that gets its sustenance from the vegetable kingdom. This is only telling, in other words, the truth that there is no primitive form of food, albuminous, starchy, osseous, in the animal world itself. We have, therefore, in procuring the animal in a state for food, to catch it, or rear it, to feed it, and tend it; to accept the loss of it from possible disease, to go to the expense of killing it and dressing it, and, in the end, to use, after all, but a portion of its carcase for that food which we require from it. All these acts mean money, and, as a rule, money over and above, in great part, that which is spent in merely collecting the primitive vegetable substances which might be as directly applied to the wants of man as indirectly through the animal. The cheapness of vegetable food is plain enough.

3. The next question is that of quality, or of goodness, amount of nourishment of different kinds. Let us test this fact in relation to amount of water in different foods. In the primest joints there is as much as 70 or 75 per cent. of water. There are some vegetables which contain more water than this, viz.: potatoes, turnips, cabbages, and carrots; but there are other vegetables which contain infinitely less water. Oatmeal, for example, contains only 5 or 6 per cent.; good wheaten flour, barley meal, beans, and peas, 14; rice, 15; and good bread, 40 to 45 of water. Taking, then, the value of foods as estimated by their solid value, there are, it will be observed, a large class of vegetable foods which, for solid value, are incomparably superior to animal flesh. Peas, beans, rice, oats, barley, and wheat, are of this class. In the animal foods named, there are 25 parts of solid matter to the 100; in the vegetable foods specially named, there are 86 parts.

If we compute from the solid matter the value of flesh-forming and strength-producing foods on the animal and vegetable produce, we find some other useful facts. In a leg of mutton we find 24 per cent. of solid material, 10·20 of albuminoids or flesh-forming substance, and 8·76 of fat or force-producing substance, the rest of it is water. Let us compare that with wheat as a favorite vegetable substance, and we shall find in the 86 per cent. of the solid matter of wheat, 11·50 of albuminoids or flesh-forming substance, and 71 of force-producing substance or starch with a little fat. Wheat is, by this calculation, much more valuable than leg of mutton, and the vegetarian would, I dare say, with fair argument, challenge many further similar comparisons. Coming, in fact, directly to matter of quality or goodness, it may honestly be admitted that, weight by weight, vegetable substances, when they are carefully selected, possess the most striking advantages over animal in nutritive value.

The practical lesson is, that man can live most healthily on a condensed vegetable diet, in combination with fresh fruits and green vegetables. Once understood as a matter of thrift, vegetable foods would soon come into general, if not into universal use. At the same time, there is this difficulty in the advancement of economy by the use of vegetable food, that many persons will always be found who, in spite of repugnance or other objection to animal food, will digest vegetable food that has been prepared for them by passing through the systems of other animals better than when they themselves take it first hand from the plant. The pulses produce in most persons flatulency and dyspepsia. Oatmeal causes in many persons heat and dryness of the skin, even when taken with lime juice or fresh fruit; and other difficulties could be named which, at the present, beset the vegetarian in his path. These difficulties are not insurmountable, but an inquiry is demanded on the point whether the transmutation of vegetable food, which now is obtained by the digestion and passage of the blood into the tissues of lower herbivorous animals, may not be effected by chemical processes, apart from the intermediate animal altogether. When the most scientific instruments possessed by man were the flint head, the iron lance, the boomerang, the sling and stone, the fowling piece, the rifle, and other weapons, for destruction of the inferior animals, or, when improving on these, he has advanced only to the process of herding and feeding animals for slaughter, this question of transmutation of vegetable feeders could not be thought of. In the present day, the circumstances are entirely changed. We know now, to a nicety, the relation of the various parts of food, for the construction of the living body from food, and there should be no difficulty, except the labor of research, in so modifying food taken from its prime source as to make it applicable to every necessity without the assistance of any intermediate animal at all. Changes quite as difficult have been accomplished by scientific labor in the laboratory, and if men of science will, in patient research for a few years, follow up the artificial digestion and condensation of vegetable foods by synthetical imitations, assuredly the perfect production of perfect food from the vegetable kingdom, without the aid of the intermediate lower animal, will be another triumph of science over nature. In the presence of such a development, food of the best kind would become the cheapest of all products, and would be so under the control of man, that new races of men, constructed on better food than has ever yet been prepared, would rise up to demonstrate the greatness of the triumph by their improved physical endowments, and their freedom from certain diseases, which must always occur so long as other living animal bodies are demanded for the reconstruction of the human body.

The quantity of food that is taken is the third particular subject in respect to thrift in food to which I would direct attention. There can be no doubt that the average amount of food taken by the majority of persons far exceeds the amount that is really necessary. The saving that might be made is, I believe, a fair half of that which is actually required by the members of the community that can claim anything approaching to a competency. It is in the great centers of population that this form of economy of food is most urgent, for it is in them that the greatest waste is carried on. In the time of the cotton famine I estimated, in respect to animal food, that the average amount consumed per day in England was 7¼ ounces per person, while in France it was under three ounces. This was by a supposed equal division of the animal food through the whole of these countries respectively; but when the estimate was applied to the metropolitan centers of these countries, it gave a consumption of twenty-two ounces per day for each person in London, and nine ounces in Paris. It is not, however, to be supposed that the enormous over-consumption of food in these great centers was food actually eaten by the people. It was food eaten, and eaten in excess, but it was also food literally thrown away, the value of which has more than once been shown by the application which has been made of it by some thrifty communities. The Sisters of Nazareth House, at Hammersmith, have been good, and, for ought I know, are still, one splendid example of these thrifty people. Out of the crumbs which fall from the tables of the rich and extravagant, and which these good women collected, they actually fed, during the cotton famine, on good sustaining food, not only their own community, but a hundred other persons who were dependent on them for support, the waste residue from every family of six persons being sufficient, when it could be collected, to keep a seventh comfortably, and in some instances, as I was advised, even a seventh and eight.

This example of thrift, if but partly copied by the people generally, would soon work an entire revolution in food economy in this country. To be effective, however, the example must come, not from little sisters of charity, but from that twenty-fifth man who heads the community, and especially—I say it in all honesty, and without a thought of offense—from him as he disports himself in such places as the City of London. It is at great and wasteful banquets that the extreme lessons of thriftlessness which so oppose thrift are set forth and praised and practiced, and it is in these centers the grand reform should commence.

In the year 1864, when I was writing for the *Medical Times and Gazette* a medical history of Wolverhampton, I chanced to reason with some colliers there, why they should spend their hard-earned wages as they did, in what they called "plaey," which means living for one day in the week on the choicest viands that could be got, ducks, geese, lamb, or asparagus, every dainty the season could yield or money purchase. In reply, one of these grimy epicures, little anticipating how his words would one day be applied, observed, "Gie up pleay, measter; why its ony a feaest loike a Lod Mayor's dinner, if ye've iver hin at un. When us betters

gie up pleay, tell us, an we wull." The retort went, and still goes home. But I take it as one of the most hopeful signs of thrift that was ever known, that, through the liberal mindedness and the earnest desire for the public good, the moral it so forcibly conveys should be at last permitted by a Lord Mayor of London himself to be repeated even from the banqueting hall of the Mansion House.

AN ASCENT OF THE GREAT PYRAMID.

THE great pyramid is so imposing and so ancient as to be worthy of figuring alongside the works of nature; and, on ascending it, one can scarcely believe that he is upon a monument made by the hands of man. "I have thought," says a writer in *La Nature*, "that a succinct account of a recent voyage made by myself to the pyramids might not prove devoid of interest to the general reader.

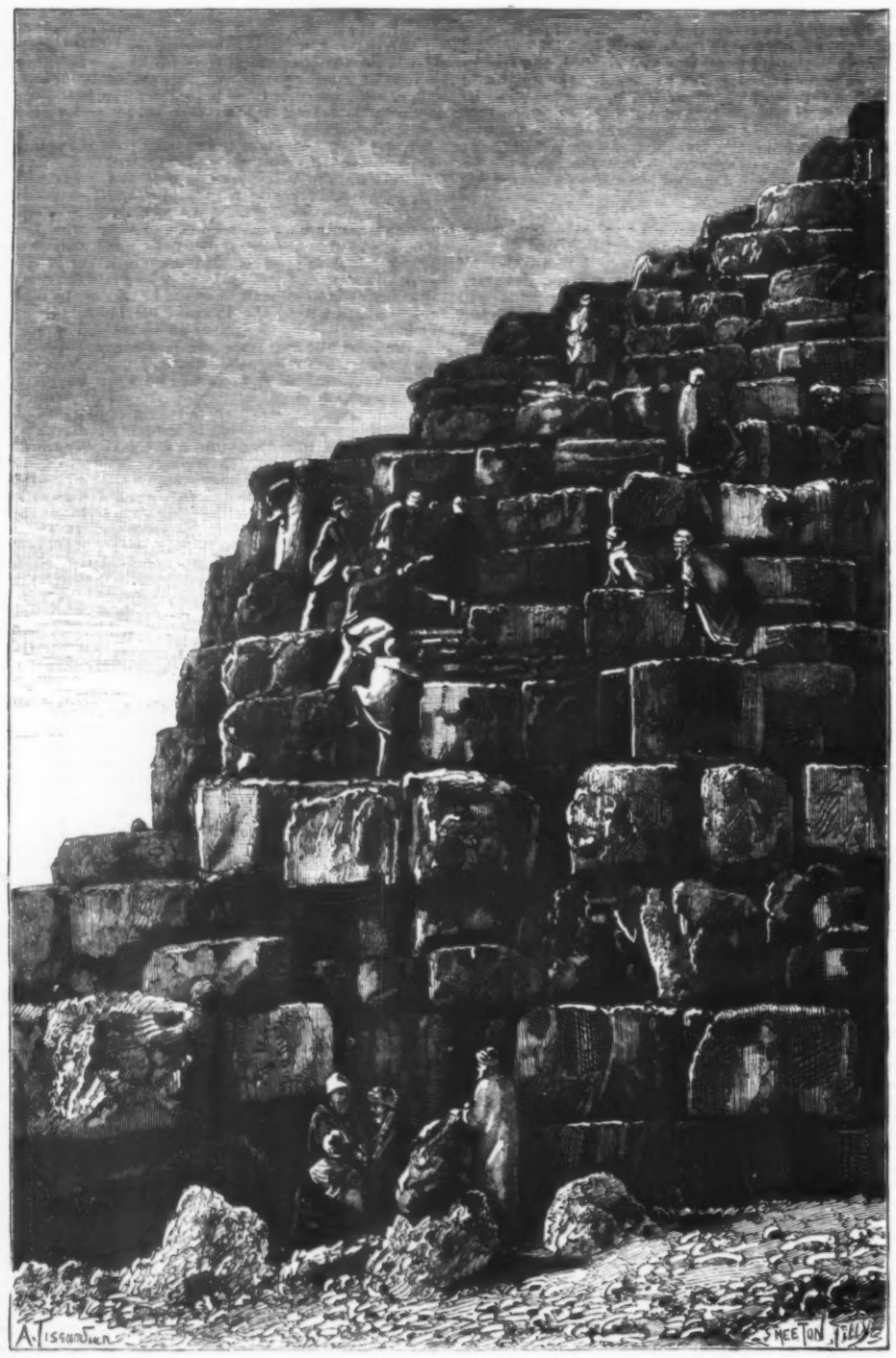
"The pyramids, when we approach them, conceal by their mighty mass the horizon of the sandy desert. I had resolved to be a witness of sunset from the apex of the pyramid of Gizeh; and as my companions and I approached the base of the gigantic structure, we were at once surrounded by a large number of Bedouins who guard and monopolize the pyramids. It is a ragged population, but, under the desert sun, is not wanting in a certain aspect of picturesqeness. As I was endeavoring to mount the first courses, these people came to my aid; and one seizing me by the hands, and another underneath raising me by the feet, I was enabled to rapidly ascend these giants' stairs, the steps of which reached my waist. A few guides preceded me on the upper courses, the ascent of which they effected with remarkable dexterity.

"When we had reached about a third of the height, we visited the funereal chamber. Preceded by torches, we entered a sort of a triangular-vaulted crypt whose marble walls bore a French inscription—a souvenir of Bonaparte's campaign. Afterward we were obliged to undertake a perilous passage, our bodies bent, and our feet resting on two narrow ledges on each side of an abyss which yawned between our legs. The Bedouins did their best to hold us up. To this frightful endless road succeeded a low gallery where it was scarcely possible for us to creep, for the ascent was very steep. There was also a well without a curb, around which we had to make our way with great care.

"Finally, having been pushed, pulled, and nearly bent double, to avoid striking our heads, and even having been carried on robust shoulders, we reached the great hall, which is small—so small, indeed, that one asks himself if the pyramid does not conceal mysteries more worthy of it. More than sixty million cubic feet of stones, piled up with art in order to inclose a vault which is no more than seventy-five or eighty feet in circumference! With the stones in the pyramid there might be built a wall, six feet high, which would easily reach around the whole of France!

"To get out of the vault required the same precaution as it did to enter it I then continued my ascent, and was soon at the top.

"The platform is a work of time, and anciently the sharp apex of the pyramid seemed to pierce the heavens. At the present time one can stand on it with ease and see in the distance the terraces of Cairo illuminated, while the Nile looks like a thread of fire under the rays of a burning sun. Unfortunately, these great pyramids which, for ages, have withstood the injuries of time, are daily becoming the object of monstrous acts of vandalism, against which no protests can be too vehement. Since my recent excursion four or five blocks have been taken from the great pyramid. I saw at Dachour, a little-frequented place, three camels being loaded with calcareous stones pulled out of the structure. It was in vain that the thieves were threatened that their work of destruction would be at once complained of to the authorities; they went on just the same, and every block they pulled out necessitated the fall of two or three others. The neighboring pyramid, which produces so beautiful an effect, is also a subject of the depredations of some demolishers or other of the vicinity. Several large blocks are wanting under the entrance way, and all around the monument other stones are seen which must have been pulled out by means of the pickax. Like acts are taking place at Sakkarah and at Maydoun; and, if the Egyptian government does not take measures to prevent it, the pyramids will be gradually destroyed. But, if recent newspaper statements are true, the government itself holds these ancient monuments in no higher estimation than some of its subjects; for it is reported that the Khedive himself has been removing sufficient material from one of the pyramids to build a mosque!"



AN ASCENT OF THE GREAT PYRAMID.

FISHERIES OF THE ISLE OF MAN.

THE Commissioners of Fisheries—Messrs. Buckland and Spencer Walpole—mention that as so much interest attaches to and so little is known of the fisheries of the Isle of Man, they think it right to append a particular reference to them in their report upon the Sea Fisheries of England and Wales. With regard to the inland fisheries, the Isle of Man is watered by several rivers, the greatest and most important being the Sulby, a river which rises near the center of the island, and flows into the sea at Ramsey. The second most important watershed is drained by the town rivers, the Dhoo, or the Black River, and the Glass, or the Clear River, which unite their waters near Douglas, and give their united names to the thriving capital of the island. The third river of importance is the Neb, which enters the sea at Peel, and the fourth is the Laxey. Other smaller streams drain other parts of the island.

There is no doubt whatever that all these streams were, at a comparatively recent period, productive salmon and sea trout rivers. The Laxey owes its name, like the Lax weir, at Limerick, to the salmon with which it abounded; and the Douglas is situated in the parish of Braddan, a word derived from the Gaelic for a salmon. Men who are still alive recollect the period when the salmon fishery of the island was a profitable business. Of recent years this has been in a very unsatisfactory condition. The fishery of the Laxey has been practically destroyed by the well known mine which takes its name from the river. The fishery of the Neb has also been destroyed by a mine, while the Douglas river is injured by the gas water of the town of Douglas. Pollution makes it impossible to hope that the salmon fisheries will ever recover their former condition. But in addition to the injury done to these fisheries by pollution, they are also suffering from the consequence of unfair fishing. The fisheries are now regulated by an old act, passed about forty years ago. The act provides a close time for salmon; it prohibits the use of certain instruments; and it professes to prevent the pollution of rivers. The authorities of the island, however, doubt the possibility of enforcing its provisions, while, in any case, the act must be a failure, now that there is no machinery for enforcing them. Analogous machinery, however, to that which is provided with the same object in England, might be easily applied to the Isle of Man.

The sea fisheries are also of importance. Peel, the chief fishing port, is one of the principal stations of the herring fishery. It has a fine fleet of first-class fishing boats, which frequent many of the principal Irish, Scotch, and English fisheries. The boats are fast, handsome, and large, and it is difficult to see a finer sight than the fleet standing out to sea on a summer's evening. The fleet usually repair in the spring of the year to Kinsale, for mackerel fishing. In the summer and autumn the herrings come into the Manx and Irish seas. The fishery is in a satisfactory condition, and there is an almost universal agreement among the fishermen that only one regulation is required, which, however, is of very great importance. A custom has arisen of late years for the fishermen to shoot their nets before sunset. The fish, scared by the early shooting of the nets, frequently sink, and the night's fishing is, in consequence, lost. In addition to the summer fishery for herrings, there used to be a considerable autumn fishery for spawning herrings off the east coast of the Isle of Man. A large so-called coral bank, many miles in length, extends from a spot off Mangold Head, to a spot off Douglas Head, in which the herrings undoubtedly spawn. There used to be a very considerable fishery for these spawning fish. The fishery has now ceased, as the nets used in it are broken by the vast shoals of dog-fish preying on the spawning fisheries. The fishermen declare that in the olden times the shoal of herrings was much larger than it is now, and that, as the dog-fish were always on the outside, they could drift for some miles through the herrings without coming on the dog-fish. They declare that now the shoal is so much smaller that they come more quickly on the dog-fish, and that the nets are then broken. The commissioners incline to think that the nets are broken, not because the shoal of spawning fish is smaller, but because the nets, which are now made of cotton, are much weaker than the old nets, which used to be made of hemp. On the other hand, it is only right to say that dog-fish, like other fish, are migratory in their movements, and that it is possible that they visit a place for some years, and then leave it altogether. This view is partly confirmed by a tradition in the Isle of Man, that a special prayer was once put up in all the parish churches against dog-fish. It was not possible to obtain a copy of the prayer, but its existence was stated on good authority. If such a prayer was raised in olden times, it is a fair inference that the present plague is not unprecedented. In addition to the herring fishery, which is chiefly carried on from Peel, there is an important hook-and-line fishery for cod conducted chiefly from Ramsey. The Liverpool trawlers fish the great breeding banks of the island, and the bays are fished by small-meshed draught nets, and by fixed trammel nets. In the island itself the long-line fishing is regarded as the most important of these industries, and the majority of people in the island are prepared to sacrifice all the other kinds of fishing for the sake of the long-line and herring fisheries.

BERNHARD VON COTTA.

THE death of Professor Cotta, at Freiberg, Saxony, on the 14th of September last, terminated an honorable and distinguished career in science, and removed from earth a genial and brilliant soul, beloved by a circle of colleagues, pupils, readers, and friends, co-extensive with the civilized nations. We are indebted to Professor Stelzner, of the Freiberg Academy, for the materials of the sketch of Professor Cotta's life and works; and we are sure that in publishing such a sketch we meet the wishes of a large number of American engineers who, like ourselves, cherish affectionate personal remembrances of the man. We regret only that our limited space does not permit us to translate and publish in full the excellent memorial of Cotta published by Professor Stelzner.

Bernhard Von Cotta was born on October 24, 1808, at Zillbach, in Eisenach, where his father, Heinrich Cotta, was, at that time, chief forester and head of the private school of forestry. Heinrich Cotta was subsequently moved to Tharand, where in 1816 he established, for the Saxon government, the famous Royal Academy of Forestry, which he rapidly and successfully developed, introducing at the same time numerous reforms in the Saxon forestry system, and

devoting himself also with zeal to the allied natural sciences. Among the results of his activity was a valuable collection of fossilized woods, and a report of local geological examinations.

Bernhard entered, in 1827, the Mining Academy at Freiberg, which he left in 1832, to complete his studies in mining law at the University of Heidelberg, where he received the degree of Doctor of Philosophy. Devoting himself, however, by preference to the natural sciences, he returned to Tharand, and employed himself with the study of his father's collections, and with geological explorations in the neighborhood. His first publications were a treatise on "Dendrolites "(1832), "A Geological Creed" (1835), and the first part of his "Geognostic Wanderings." His ability was speedily recognized by an appointment as assistant to Prof. C. F. Naumann, in the preparation of the geognostic map of Saxony. Having charge of the eastern part of the kingdom, he had to deal with the peculiar and perplexing stratigraphic relations of the granite, Jura lime, and quader-sandstone at Hohenstein—a problem which, in that day, commanded so much attention from geologists that the enthusiastic young investigator was able, with the aid of such *savants* as Humboldt, Leonhard, and De Beaumont, to carry out a plan for a series of excavations, for the sole purpose of studying the facts in the interest of science. The expenses of this operation were paid by the voluntary subscriptions of German geologists—an instance perhaps without a parallel in the history of geological explorations. The result was the demonstration (1838), in the second part of the "Geognostic Wanderings," that, at Hohenstein and other points of the zone, extending from Saxony to Bohemia, peculiar slides or overthrows had brought the older geological formations above the later ones.

The labors of Cotta upon the survey of Saxony and Thuringia lasted until 1847, when the map of Thuringia was published. Meanwhile, he became, in 1839, connected with the Tharand Academy, as Secretary of which he published, in 1842, the first number of the "Forestry Annual." In the latter year, he was called to the Freiberg Mining Academy, to occupy, upon the removal of Naumann to Leipsic, the chair of geognosy, which he retained until 1874; lecturing during the whole of this period of thirty-two years upon geognosy, and, from 1843, upon paleontology, and from 1851, upon the science of mineral deposits. All students of general economic geology are aware that this period was one of great and useful activity on the part of a circle of instructors connected with the Freiberg Academy, which has left its indelible marks upon both the practice and the literature of mining metallurgy. The impulse given by Werner, the father of modern geology, to the study of that science was worthily continued by his successors and pupils; while the different branches of mining, engineering, metallurgy, and mineralogy, were pursued with enthusiasm and industry, and with most fruitful practical results. We need only mention the names of Friesclaves, Beusd, Breithaupt, Gaetzschmann, Reich, Richter, Scheerer, Plattner, Friezche, and the two Weisbachs, to prove the truth of this assertion. Pupils of these men are found in all parts of the world, and their books, translated into many tongues, are recognized as authorities of the first rank. No one among them was more productive than Cotta, who published a considerable number of manuals and text books, primarily intended for his own classes, but rapidly attaining a wider circulation; almost innumerable reports on mines and mining enterprises, geological reconnoissances, and treatises, both popular and technical, upon dynamic geology. Among the text books on geology is "Die Gesteinlehre" (1855; second edition, 1862; English translation by Lawrence, "Rocks Classified and described; a Treatise on Lithology," 1866; second edition, 1878). His "Lehre von den Erzlagerstätten (1855; second and enlarged edition, 1859–61) is well known to American readers from the translation of Professor Prime (1870). The interesting and valuable "Gangstudien" (3 volumes and the fraction of a fourth, published in Freiberg from 1847 to 1862) have never been translated, and perhaps would not, on the whole, repay a republication. The different articles, by different authors, vary in value. Some of them, however, like Weissenbach's "Classification of Mineral Veins," are classics and oft-quoted authority. The views of Oscar Lieber, the brilliant young geologist of South Carolina, concerning the gold bearing deposits of the Southern States, were first published in this work, although they appeared in substance in Lieber's subsequent English report.

BERNHARD VON COTTA.

Cotta, more than any other writer, may be called the leader in the Saxon school in the science of ore deposits. The classification into types which he pursued—and he refers all ore deposits to classes comprising veins, beds, masses, impregnations—is not a perfectly satisfactory one from the stand point of science. Its leading distinctions rest too much upon accidental features, and particularly upon the form of the deposits; but, as Professor Stelzner well remarks, the weight of Cotta's writings goes to demonstrate throughout that ore deposits are local phenomena which must be studied in their individuality, and their formation is not to be prophesied or inferred from any sweeping geologic or geographic formulas. Against such a dictum as that of Murchison, who referred the gold deposits of the world to the Silurian rocks exclusively, or that of Beaumont, who connected the metalliferous deposits with an ingenious law of "pentagonal symmetry," Cotta constantly argued. We may add, concerning his classification, that it has its advantages for the mining engineer, however it may be criticised by the geologist and mineralogist; for the very distinctions of form which seem to be scientifically insignificant are those which often determine all the plans and details of mining operations.

As a geologist, Professor Cotta can scarcely be said to have been attached to the extremists of any school. He followed, with conservative spirit, the theories of the chemical geologists, and occupied, on the whole, nearly the attitude which was taken in England by Lyell. Like the latter, but with more readiness, he gave his assent to the hypothesis of Darwinism; and in his famous work, "Die Geologie der Gegenwart" (published in 1866, on the occasion of the centennial of the Freiberg Academy), he extended the principle of development over the whole inorganic world. This work was more popular than technical, and contained little that was new to scientific men; but it constitutes an admirable summary of the existing state of geological inquiry, presented in a charming style and illustrated from the stores of an abundant experience. To use the author's own words, the fundamental thought of the work is gradual development by the constant summation of individual effects—a natural law, of which Darwin's theory of species is only a special application to organic life.

In 1876, Professor Cotta formed the plan of a history of geology; but only the introductory volume was ever finished. This appeared in 1877, under the title of "Geologisches Repertorium," containing a chronological catalogue of geological publications down to the end of 1876. Incomplete as it is in many respects, it is nevertheless a most valuable work, and reflects much credit upon the tireless industry of its compiler.

Professor Cotta edited a considerable number of important translations from foreign languages, including several treatises by Fournet and a German version of Lyell's Geology. His contributions to various periodicals and his general literary work it is almost impossible to enumerate. Perhaps the most important book which we have not yet mentioned is the "Letters upon Humboldt's Cosmos," comprising two volumes, both of which, in their time (thirty years ago), attracted much attention, and were both heartily praised and severely criticised.

To us, and we cannot doubt to thousands of others, the impression produced by the writings of Bernard von Cotta is inseparable from the personality of the man. His restless activity, genial humor, and cordial hospitality; his fidelity and friendship; his patience, skill, and tact as a teacher; his merry, boyish spirit as a comrade in the field, endeared him to successive generations of young men, who now, from every civilized country in the world, look back upon their student days at Freiberg with affectionate remembrance. Will there ever again be such geological excursions to Meissen as, under Cotta's leadership, there used to be?

We recall with pleasure a day in 1873, when we revisited, for a few brief and pleasant hours, the old town and the old school. Time had wrought great changes in both. Scheerer, Cotta, and Gaetzschmann had already practically ceased their active labors of instruction. The elder Weisbach was gone. A railroad station had made its appearance in the suburbs as a type of the new era, and in a chamber of that modern building a few of the old professors honored us with a social gathering; the past cheerfully accepting the changes of the present, and looking forward with quiet expectation of the future.

In the beginning of 1877, a stroke of paralysis, disabling the left side of Professor Cotta, gave notice of the approaching end. He failed gradually in bodily strength, though apparently not in clearness of intellect, until, on the 14th of last September, he fell asleep.—*Engineering and Mining Journal.*

SYNTHETIC STUDIES OF EXPERIMENTAL GEOLOGY.

IT is not till now, after a century of incessant effort, that an experimental geological school has at length been established; and the book that M. Daubrée, the French geologist, has just published, will mark the point of departure of a new period in geologic science. It is not here a question solely of experiments in regard to problems that have been already more or less resolved, but it is a collection of new doctrines that we come into possession of—a general method that had not hitherto been applied in a scientific manner to the study of the globe, in other words, experimental synthesis. M. Daubrée's volume is in two parts, one relating to geological phenomena, properly so called, and the other to the study of meteorites. Of the latter, we shall at present say nothing. The geological portion is divided into two sections, one of which relates to chemical and physical phenomena, and the other to mechanical ones. The latter is by far the newer.

Among chemical phenomena, the author devotes himself especially to the genesis of minerals, and particularly those which characterize the metamorphic rocks. Under these two headings are given numerous experiments, some of which have been performed in the ordinary laboratory of the chemist, and others have taken place of themselves in the substance of Roman sub-structions that have been constantly impregnated with thermal waters for two thousand years. As for the mechanical phenomena, we will have to pay them a little more attention. M. Daubrée first studies the contours of the stratified rocks. With one of the simplest of apparatus, consisting of an iron frame provided with long screws passing through two of its contiguous sides, he submits flexible plates, representing the earth's strata, to the most varied pressures. Under these efforts, constantly measured, he finds all the characteristic features of the globe reproduced—synclinal valleys, anticlinal crests, dips and overturning of strata, etc. He goes still farther, and, exceeding the limits of the elasticity of the bent plates, he enters upon the chapter of the origin and mode of formation of terrestrial fractures. By this new method, seams and fissures are imitated in all their details, and, quite unexpectedly, the study of the experimental results has revealed features of mutual co-ordination in the fractures that observation alone had almost overlooked. This fact merits our attention. A rectangular glass plate, G G (Fig. 1), is firmly grasped at one end by the two chaps of a sort of wooden vise, E E, and the other end held in a tap-wrench, T T. By causing the latter to move around a horizontal axis the glass plate is twisted and quickly broken into a thousand bits. If care has been taken to glue a sheet of paper to the glass so as to preserve the arrangement of the *débris*, it will be seen with surprise that the fractures, far from being arranged in a haphazard way, will exhibit a geometrical regularity. The fractures will be found grouped so as to follow two directions or systems, both inclined toward the axis of torsion. Generally these two systems thus conjoined cross one another at very open angles, the size of which appears to depend on the relative dimensions of the two sides of the plate. Sometimes the intersections are

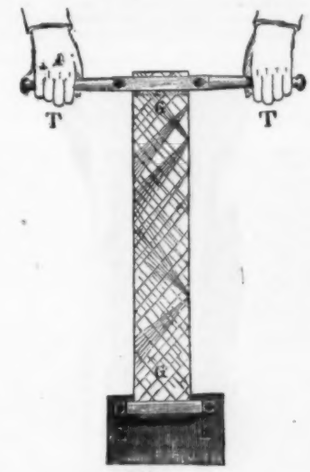


FIG. 1.

Double System of Fractures in a Glass Plate, caused by torsion. (½ actual size.)

nearly at right angles; in other cases they take place at an angle of 70° and less. Now these artificial fractures are found to have close analogies with certain geological features of different regions; and, among the examples of localities where the correlation of subterranean fractures with surface elevations are strikingly seen, we may cite the cretaceous strata of a part of the north of France. Upon a close examination of an accurate map it will be seen that from the principal valleys lying parallel to each other there branch out a large number of valleys, which are also rectilinear and parallel with each other. We see how the thin pellicle, which we call the terrestrial crust, has ceded to torsions analogous to those produced on the glass plate by the tap-

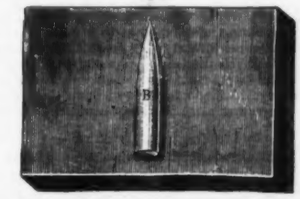


FIG. 2.

Belemnites niger, B, inserted in the centre of a leaden block formed of two parts, one only of which is here shown. (Scale ½ actual size.

wrench, and has been fissured in directions co-ordinated one with the other.

M. Daubrée also studies, by experimental methods, the deformations that fossils have undergone in schistose rocks. The fact is well known that it is rare to find any remains of trilobites and mollusks in the vicinity of Angers that have not been so deformed as to make them mere caricatures of what they were originally. Experiment allows these to be closely imitated. By inclosing the head of a craw-fish in a mass of lead and then passing the latter through a flatting machine, the crustacean is deformed exactly like the silurian trilobites. A remarkable type of alteration of form of the fossils contained in schistose rocks is presented by the belemnites of different

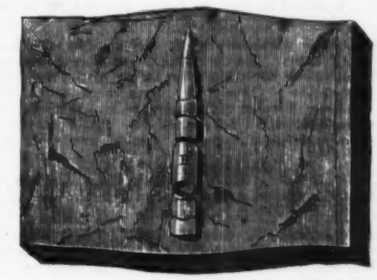


FIG. 3.

Fracture and separation of the parts of the Belemnite of the preceding figure, through the hydraulic pressure to which the leaden matrix has been submitted.

Alpine localities, and which have been truncated, their different segments being more or less separated from each other. This has also been reproduced by experiment by laminating blocks of lead in which belemnites had been previously inserted. Fig. 2 represents such a belemnite, B, inclosed in its leaden matrix, half of which only is represented. Fig. 3 shows the effect produced by lamination:

the fossil has been truncated, and its segments have been separated from each other, exactly as in natural specimens. It is by pursuing the same class of researches that the author succeeds in imitating the characteristic structure of the great mountain chains, as observed by Saussure, at Mont Blanc. "The mass of Mont Blanc," say this celebrated observer, "is divided into great folds, having their planes exactly parallel to each other, and also parallel to the direction of the chain." Moreover, these folds, which are nearly vertical in the center of the mass, assume inclined positions in the lateral portions, and dip symmetrically toward the central axis, so as to exhibit in this transverse section the form of a partially outspread fan. Now, Mont Blancs in miniature, having the structure described by Saussure, can be reproduced experimentally. This is how it is done: Clay is first

FIG. 4.

Production of the fan-shaped structure in a mass of clay forced by pressure between two parallel plates. ⅔ actual size.

well kneaded, and, when nearly dry, cut into the shape of a square prism. It is then placed between two square plates of the same dimensions as the prism, and submitted to the action of a hydraulic press. During this operation there issues from each of the four lateral faces a seam whose form, flattened by change of pressure, unites with the faces of the prism. The misshapen mass exhibits in its transverse fracture a texture which is essentially schistose, and which is thus arranged: In all that portion compressed between the plates the layers are nearly parallel with the two sides, but in the portion extending beyond the plates the layers bend outward, away from the axis, so as to become parallel to the two outer surfaces, and tend to separate more and more from each other. The lamination is specially marked near the two external surfaces, but is in general much less so near the central part. This experiment furnishes, then, a *fac-simile* (Fig. 4) in miniature of the laminated structure called fan-shaped.

[Continued from SUPPLEMENT No. 228, page 3638.]

FOREST TREES OF NORTH AMERICA.

By CHARLES S. SARGENT, Arnold Professor of Arboriculture in Harvard College, Special Agent Tenth Census.

71. *Cercis occidentalis*, Torr. *C. Californicum*, Torr. (Red Bud. Judas Tree.) California, Mount Shasta, and Mendocino County, southward along the foothills of the Sierras to San Diego. A small tree, or more frequently a large shrub. A small shrubby variety (*C. reniformis*, Engelm.) occurs in Southern Texas and New Mexico.

72. *Prosopis juliflora*, DC. *Algarobia glandulosa*, Torr. and Gray. (Algaroba. Mesquite. Honey Locust.) Valley of the Guadaloupe, plains of Western Texas to San Felipe Cañon, Southern California; north to southern Colorado and southern Nevada; and southward through Mexico. Wood hard, very heavy and durable, affording fuel of the best quality and excellent charcoal. The unripe and pulpy pods edible and a valuable forage. A gum resembling gum-arabic is produced by this tree, and the seeds are rich in grape-sugar. "Trees 30 to 40 feet high, with few and large erect branches; the trunk often from one to two and one half feet in diameter; the heartwood dark reddish brown, but often occurring as a small tree or shrub. Important as furnishing the only firewood in Western Texas, and also for its edible fruit."—Lindheimer. Gray, Pl. Lindh., 181.

73. *Prosopis pubescens*, Benth. *Strombocarpa pubescens*, Gray. (Tornilla. Screw Bean. Screw-pod Mesquite.) Southern New Mexico, along the valley of the Rio Grande; west to San Diego County, California; north to Ash Meadows, southern Nevada; and southward into Mexico. Wood resembling that of the last species. A small tree; the seeds affording excellent forage; or, ground into flour, Indian food.

74. *Acacia greggii*, Gray. Western Texas, through southern New Mexico and Arizona to San Diego, California. A small tree, 10 to 20 feet in height.

75. *Pithecolobium unguis-cati*, Benth. *Inga unguis cati*, Willd. *P. Guadalupense*, Nutt. (Cat's-claw.) Southern Florida, and through the West Indies. A small tree, 10 to 20 feet in height.

ROSACEÆ.

76. *Prunus Americana*, Marshall. (Wild Plum. Canada Plum.) From Hudson's Bay to Florida; west to Denver City, Colorado, Shawneetown, Indian Territory, and Central Texas. Wood reddish, hard. A small tree; often cultivated for its red or yellow acid fruit.

77. *Prunus Caroliniana*, Ait. *Cerasus Caroliniana*, Michx. (Mock Orange.) North Carolina to Florida, near the coast, and west to Louisiana, Arkansas, and Eastern Texas. Wood rose-colored, fine-grained, brittle. A small tree, sometimes 40 feet in height; often cultivated for ornament.

78. *Prunus Chicasa*, Michx. *Cerasus Chicasa*, Sering. (Chickasaw Plum.) Probably native in the regions immediately east and southeast of the Rocky Mountains, but now widely naturalized in all the Atlantic States south of Pennsylvania and Illinois. A small tree, or often a shrub; frequently cultivated for its globose, red and yellowish fruit.

79. *Prunus emarginata*, Walpers; *var. mollis*, Brewer. *P. mollis*, Walpers. *Cerasus mollis*, Dougl. Northern California to Puget Sound, and east into the Cascade Mountains. A small tree, sometimes 30 feet in height. Common in Oregon and Washington Territory. The shrubby *P. emarginata*, Walpers, is the common form of California.

80 *Prunus Pennsylvanica*, L. *Cerasus borealis*, Michx. *Cerasus Pennsylvanica*, Sering. (Wild Red Cherry.) From Newfoundland to the headwaters of the Saskatchewan; throughout the New England and Northern States; on the high mountains of North Carolina, and in the Rocky Mountains of Colorado. A small tree, sometimes 30 to 40 feet in height. In northern New England, taking possession of the immense tracts annually cleared of the coniferous forests by fire.

81. *Prunus serotina*, Ehrh. *Cerasus Virginiana*, Michx. *Cerasus serotina*, Loisel. *P. capollin*, Zucc.? (Wild Black Cherry.) Hudson's Bay, south to Florida, and from the Atlantic coast to Eastern Nebraska, the Indian Territory, Eastern Texas, and probably further southwest. Wood light red, becoming darker with age, close-grained, compact, light, easily worked, and not liable to warp; its specific gravity, 0·454; largely employed in cabinet-making, for which it is one of the most valuable of North American woods. A tree 60 to 80 feet in height, with a trunk often 4 feet in diameter; reaching its greatest perfection in the valley of the Ohio.

82. *Prunus umbellata*, Elliott. South Carolina, to Florida and Alabama. A small tree, often a shrub; "in very dry and sandy soils."—Elliott.

83. *Nuttallia cerasiformis*, Torr. and Gray. (Oso Berry.) From San Luis Obispo, California, north to Puget Sound; along the coast ranges in California; in Oregon and Washington Territory, east into the Cascade Mountains. A small tree, or often a shrub.

84. *Cercocarpus ledifolius*, Nutt. (Mountain Mahogany.) Wasatch Mountains, Utah, west to the eastern slopes of the Sierra Nevada; and from the 36th parallel north into Oregon and Idaho. Wood mahogany-colored, very hard, remarkably heavy, and susceptible of a beautiful polish, although too brittle and difficult to work to be useful in the arts; furnishing the most valuable fuel of Nevada; its specific gravity 1·117. A small tree, sometimes 40 feet in height, and often only a shrub. Very common in all the mountain ranges of the "Great Basin" at 6,000 to 8,000 feet elevation.

85. *Pirus Americana*, DC. *Sorbus Americana*, Marsh. (American Mountain Ash.) Greenland and Labrador, south through the New England and Northern States, to Wisconsin; on the high peaks of the mountains of North Carolina. A small tree; in swamps and moist woods.

86. *Pirus angustifolia*, Ait. *Malus angustifolia*, Michx. (Narrow-leaved Crab Apple.) From ——? Pennsylvania to Florida and Mississippi; probably confined to the low country and not ascending or crossing the Alleghany mountains. A small tree.

87. *Pirus coronaria*, L. *Malus coronaria*, Mill. (American Crab Apple.) From Oneida County, New York, west to Wisconsin, and south to Georgia, Arkansas, and Louisiana; in the South Atlantic States, only along the Alleghany Mountains. A small tree, sometimes 30 feet in height; fruit small, yellowish green, and exceedingly austere.

88. *Pirus rivularis*, Dougl. *Malus rivularis*, Desne. (Oregon Crab Apple.) From Sonoma County, California, north to Alaska; in Oregon and Washington Territory, east into the Cascade mountains. Wood hard, tough, susceptible of a good polish. A small tree, sometimes 30 feet in height; more often shrubby, and forming low, impenetrable thickets; fruit small (the size of a pea), sweet, edible. Common along streams in moist ground.

89. *Pirus sambucifolia*, Cham. and Schlect. *Sorbus sambucifolia*, Rœm. On the high mountains of New England, and far northward; along the northern frontier of the United States; in the Rocky Mountains of Colorado and Utah; on the East Humboldt range of Nevada; in the Sierra Nevada, from "Big Tree Road" northward, and in all mountain ranges north to Sitka, and in Kamtschatka. A small tree.

90. *Crataegus æstivalis*, Torr. and Gray. (May Haw. Apple Haw.) South Carolina to Florida; west to Louisiana and Arkansas. A small tree, sometimes 30 feet in height, margins of streams and ponds, in sandy soil.

91. *Crataegus apiifolia*, Michx. Virginia? to Florida, near the coast; west to Louisiana, Arkansas, and Eastern Texas. A small tree.

92. *Crataegus arborescens*, Elliott, Near Fort Argyle, on the Ogeechee River, Georgia (Elliott) to Florida, Louisiana, and Eastern Texas. A small tree, 20 to 30 feet in height; on banks of streams.

93. *Crataegus berberifolia*, Torr. and Gray, Fl. i., 469. Prairies of Opelousas, Louisiana (Prof. Carpenter). A small tree, 20 to 25 feet in height.

94. *Crataegus coccinea*, L. (Scarlet-fruited Thorn.) Canada and Northern Vermont, southward to Florida, and west to Eastern Nebraska. A small tree, 10 to 20 feet in height, running into various forms; the best marked var. *populifolia*, Torr. and Gray, Fl. i., 465, and var. *viridis*, Torr. and Gray, l. c.

95. *Crataegus cordata*, Ait. (Washington Thorn.) Virginia and Kentucky, southward to Georgia. A small tree.

96. *Crataegus crus-galli*, L. (Cockspur Thorn.) Canada and Northern Vermont, south to Florida; west to Missouri, Arkansas, and Eastern Texas. A small tree, 10 to 20 feet in height, running into various forms; the best marked var *pyracanthifolia*, Ait. Hort. Kew. ii. 170; var. *ovarifolia*, Lindl. Bot. Reg. xxii. t. 1860; var. *linearis*, DC. Prodr. 2, 626; and var. *prunifolia*, Torr. and Gray, Bot. Reg. xxii. t. 1868.

97. *Crataegus Douglasii*. Lindl. *C. sanguinea*, var. *Douglasii*, Torr. and Gray. On Pit River, California, northward to Puget Sound, and east to Montana. A small tree, 10 to 20 feet high, common in Oregon and Washington Territory along streams.

98. *Crataegus flava*, Ait. (Summer Haw.) Virginia, southward to Florida, and west to Southern Arkansas. A small tree, 10 to 20 feet in height, "in shady, sandy places."—Torrey and Gray

99. *Crataegus rivularis*, Nutt. Sierra and Plumas Counties, California; north to Puget Sound, and probably east to Montana. A small tree, 10 to 20 feet in height.

100. *Crataegus spathulata*, Michx. *C. microcarpa*, Lindl. Virginia, southward to Florida, and west to Louisiana, Arkansas, and Eastern Texas. A small tree, 10 to 20 feet in height, or often a shrub.

101. *Crataegus subvillosa*, Schrad. *C. coccinea*, var. *mollis*, Torr. and Gray. *C. tomentosa*, var. *mollis*, Gray. *C. mollis*, Scheele. Davenport and in Fremont County, Iowa; south through the valley of the Mississippi River; Shawneetown, Indian Territory, and San Antonio, Texas; the range of this species still obscure. A small tree.

102. *Crataegus tomentosa*, L. (Black Thorn. Pear Thorn.) Northern Vermont to Georgia; west to Iowa and Arkansas. A small tree, or more often a shrub. *Var. punctata*, Gray. *C. punctata*, Jacq. Canada and Northern Vermont to Georgia and Alabama; west to Wisconsin, Eastern Nebraska and Arkansas. Wood hard, heavy, close-grained. A small tree, sometimes 30 feet in height.

103. *Crataegus species*. A *Crataegus* of the Rocky Mountains of Colorado, Utah, and Wyoming, and the Clover Mountains of Nevada, which has been generally referred to *C. rivularis*, Nutt., will probably be found to be a distinct species.

104. *Heteromeles arbutifolia*, Rœmer. *Crataegus arbutifolia*, Poir. *Aronia arbutifolia*, Nutt. *Photinia arbutifolia*, Lindl. *Mespilus arbutifolia*, Link. *Photinia salicifolia*, Presl. *H. Fremontiana*, Desne. (Toyon. Tollon.) California, Mendocino County to San Diego, in the coast ranges, and east to the foothills of the Sierra Nevada. A shrub, or near San Diego a "tree 12 to 20 feet high."—Rothrock.

(*To be continued.*)

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